

**Report of the Experts' Committee Constituted by the
Government of India to Study and Report on the
Techno - Economic Feasibility of Locating
Additional Refining Capacity in Assam**

CONFIDENTIAL

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ACKNOWLEDGEMENTS

The Experts Committee places on record its appreciation of the valuable assistance rendered by the Indian Institute of Petroleum, the Indian Oil Corporation, and the Oil & Natural Gas Commission in collating and computing certain data relevant to the studies undertaken by the Committee. But for the unstinted cooperation offered by these Organizations the Committee would not have been able to complete its work within the time available to it.



CHAPTER I

1.0 Introduction

1.1 This Experts' Committee, consisting of (i) Shri B. S. Negi, (ii) Dr. Hari Narain, (iii) Dr. M. G. Krishna, (iv) Dr. A. K. Ghosh, (v) Shri S. D. Bhambri and with Shri B. S. Negi as the Convener, was constituted by the Government of India, Ministry of Petroleum & Chemicals and Mines & Metals (Department of Petroleum), vide Resolution No. 25(1)/68—OR, dated 2-4-1969, to study and report on the following :—

- (i) Crude oil resources of Assam, yearly rate of production from the various fields and the quantities that will remain available after meeting fully the requirements of the existing refineries at Digboi, Gauhati and Barauni operating to their optimum design capacities.
- (ii) The nature and extent of demand for petroleum products within the State of Assam existing and in future, and the area of economic distribution for marketing the additional production.
- (iii) Techno-economic feasibility and comparative economics of establishing a new refinery or expansion of one or more of the existing plants, taking also into account the means of transport available or proposed.
- (iv) Other relevant factors which may have a bearing on the establishment of the additional refining capacity in Assam.

1.2 The Committee was also required to consider the views of the Government of Assam and others on this subject and was required to submit its report to the Government of India within a period of three months. A copy of the above mentioned resolution of Government is placed at Annexe I.

1.3 For making the study, the Committee obtained information on the relevant matters from the various organisations concerned. The subjects on which and the authorities from whom the information was requested, and the particulars of the Committee's letters and the replies thereto are listed briefly in Annexe II.

1.4 As there is bound to be a substantial time lag between a decision to establish a new refinery based on Assam crude and the new refinery developing its full throughput as per its design capacity, the Committee is of the view that the proposed study should be based on the forecast of the availability of crude oil from Assam and the demand for petroleum products in Assam and the other regions concerned for 1975 on the basis of the data as available at present.

CHAPTER II

2.0 Crude oil resources of Assam, the yearly rate of production from the various fields and the quantities that will remain available after meeting fully the requirements of the existing refineries at Digboi, Gauhati and Barauni.

2.1 Estimates of reserves of crude oil in Assam

2.1.1 The Oil & Natural Gas Commission (ONGC), the Oil India Limited (OIL) and the Assam Oil Company (AOC) are the only oil producing organisations operating in Assam. The figures of the reserves of crude oil contained in their respective fields in Assam have been furnished by these three organisations. The total recoverable reserves as on 1-10-1968 in the case of the fields of ONGC and as on 1-1-1969 in the case of the fields of OIL and AOC are as given below :—

A + B Category/proved reserves which are considered equivalent to A + B Category	...49,379 million tonnes.
C ₁ Category/indicated reserves which are considered equivalent to C ₁ Category	...21,116 million tonnes.
Total of A + B Category/proved reserves and C ₁ Category/indicated reserves	...70,495 million tonnes.

2.1.2 AOC has given additionally a figure of C₂ Category of reserves in its field. However, this figure is negligibly small, and C₂ Category reserves are in any case untested reserves. It cannot be said definitely whether or not the crude oil is really there. Therefore, C₂ Category of reserves have not been included in the figures above. The Committee further understands that according to the existing practice geological reserves in C₂ Category are estimated only for the purpose of planning the exploration work and recoverable reserves in C₂ Category are not worked out.

2.1.3 The Committee took note of the views of the Government of Assam as brought out in the brochure "The State Government's Case for creation of additional refining capacity in Assam" (p. 12) that "the future production of the Oil & Natural Gas Commission fields has been estimated as 1.25 million tonnes in 1970 hopefully increasing to 3.0 million tonnes in 1975." These estimates were substantially at variance with the ONGC estimates obtained informally. The Committee, therefore, felt the need to get the ONGC estimates of reserves and production examined by independent experts. The Committee, with the approval of the Government of India, requested two experts, namely (i) Shri M. B. Ramachandra Rao, who was formerly the Member (Technical) of ONGC and had retired several years ago and (ii) Dr. I. P. Sokolov, Soviet Senior Geological Adviser to ONGC, jointly to examine ONGC estimates of crude oil reserves in its fields in Assam. The Committee requested these two experts also to estimate the yearly availability of crude oil from the ONGC fields in Assam during the next 15 years, taking into account all relevant factors. Accordingly, the ONGC estimates of crude oil reserves and of crude oil availability were jointly examined by Shri M. B. Ramachandra Rao and Dr. I. P. Sokolov. They presented their report on 19-6-1969.

2.1.4 In making their examination, the experts took into account not only the figures of the recoverable reserves of crude oil in A + B and C₁ Categories in the ONGC fields in Assam as on 1.10.1968, as furnished to the Committee, but also the ONGC estimates (as of 1.10.1968) of C₂ Category reserves in its Assam fields, and additional technical data obtained from drilling operations conducted subsequent to 1.10.1968 (upto 1.6.1969).

2.1.5 In their report Shri Rao and Dr. Sokolov have stated, inter-alia, that they agree that the ONGC estimates of oil reserves classified under A+B, C₁ and C₂ Categories in respect of the ONGC fields in Assam as on 1.10.1968 are reasonable and that they have no modifications to suggest, excepting those warranted by the assessment of the data obtained subsequent to 1.10.1968 and upto 1.6.1969.

2.1.6 In regard to the additions that should be made to the Commission's figures of the reserves, as a result of the additional data obtained subsequent to 1.10.1968 and upto 1.6.1969, Shri Rao and Dr. Sokolov have worked out the following figures :—

Recoverable reserves			(million tonnes)
A+B Category	...	...	0.360
C ₁ Category	...	...	0.781
Total additional recoverable reserves in A+B and C ₁ Categories			1.141
Geological reserves in C ₂ Category	...	...	15.143

2.1.7 Shri Rao and Dr. Sokolov have stated that the above mentioned figure of 15.143 million tonnes of geological reserves in C₂ Category, which pertains to a new area in which the possible pay zones and the extent thereof are yet to be tested, should be treated as purely provisional.

2.1.8 The Committee accepts and adopts the experts' estimates of the additional reserves in the ONGC fields, based on the data obtaining from drilling operations subsequent to 1.10.1968. As a result, the estimate of recoverable reserves in A+B and C₁ Categories of 70.495 million tonnes as given in para 2.1.1 above would increase by 1.141 million tonnes. Thus the total recoverable reserves in Assam of 71.636 million tonnes pertain to estimates in respect of OIL and AOC as of 1.1.1969 and in respect of ONGC as of 1.6.1969.

2.2 Estimates of yearly crude oil production from Assam oil-fields

2.2.1 ONGC, OIL and AOC have furnished to the Committee their estimates of the crude oil production rates from their respective fields in Assam in the current year and the next several years. The total estimated crude oil production from Assam is as given below :—

Year	Crude oil production (million tonnes)
1969	3.4047
1970	3.4106
1971	4.1263
1972	4.1167
1973	4.1060
1974	4.0955
1975	3.6965 (4.0865)
1976	3.2580 (4.0780)
1977	2.8900 (4.0700)
1978	2.5830 (3.7630)
1979	2.3470 (3.5570)

Note :— The figures outside the brackets give the oil production rate by primary recovery only. The figures within brackets represent the production rates assuming the benefits of pressure maintenance in Nahorkatiya and Moran fields. The Committee understands that ONGC is not in a position, at this stage, to state whether pressure maintenance in their fields would be feasible.

2.2.2 It will thus be seen that as per estimates furnished by ONGC, OIL and AOC in respect of their respective fields, the maximum production rate from Assam will be 4.1263 million tonnes per year and will be attained in 1971. In the course of the years, the production rate will progressively decrease and attain in 1979 a value of 2.3470 million tonnes ; however if benefits of pressure maintenance in Nahorkatiya and Moran fields are assumed, the production in 1979 will be 3.5570 million tonnes.

2.2.3 Shri Rao and Dr. Sokolov, who had been requested by the Committee to estimate the availability of crude oil per year during the next 15 years from ONGC fields, taking into account all relevant factors, have expressed the view that it should be possible to obtain additional crude oil production of 0.10 million tonnes per year from the Rudrasagar field and 0.40 million tonnes per year from the Lakwa field, for the next 15 years, in addition to the production rates envisaged by the Commission. They have thus envisaged an increase of 0.50 million tonnes per year in the crude oil production rate from these two fields together, over the production rate envisaged by the Commission.

2.2.4 According to Shri Rao and Dr. Sokolov, the increase in the crude oil production rate from Rudrasagar should be possible because of the observed increase in the recoverable reserves in the A+B and C₁ Categories together by about 1.5 million tonnes, subsequent to the preparation of the technological scheme for the development of the Rudrasagar field.

2.2.5 In regard to crude oil production from Lakwa, Shri Rao and Dr. Sokolov have pointed out that the existing technological scheme for development of the field had been prepared in respect of the main oil pool only and not the other pools and that, as per production plan envisaged by the ONGC, only about 50% of the recoverable reserves would be produced over a period of 15 years. Shri Rao and Dr. Sokolov have, therefore, expressed the view that it should be possible for the Commission to obtain crude oil production from the Lakwa field for the next 15 years at a rate 0.4 million tonnes per year higher than the rate envisaged by the Commission. For this purpose, Shri Rao and Dr. Sokolov have recommended dual completion of wells in the field.

2.2.6 In view of the difference between the estimates of ONGC and those of Shri Rao and Dr. Sokolov in regard to oil production rates from Rudrasagar and Lakwa, the Committee felt it necessary to obtain the oral evidence of the Specialists of the ONGC as well as of Dr. Sokolov. Accordingly, the Committee discussed the matter with ONGC Specialists and Dr. Sokolov.

2.2.7 The Specialists of the ONGC explained that for drawing up a techno-economic scheme for development of an oil field, the initial maximum Efficient Rate of production (initial MER) per well has to be fixed, taking into consideration all the relevant factors, e. g. the productivity index, water cutting, sand cutting, etc., and the well spacing (which determines the number of production wells to be drilled) has to be selected on the consideration of the economics, after studying the comparative economics of a large number of variants of well spacing. The Specialists were strongly of the view that as the technological scheme for the development of the Rudrasagar field had been drawn up on the basis of the most favourable variant on techno-economic considerations, it would not be possible to make any material increase in the optimum crude oil production rate from the field, even though there had been some increase in the recoverable reserves.

2.2.8 Shri Rao and Dr. Sokolov had pointed out that "the technological scheme of 1967 did not take into consideration the available oil reserves in the eastern blocks (of the Rudrasagar field) for production, as the parameters were then not fully known". The ONGC Specialists pointed out that the reserves in the eastern part of the field constitute only a very small percentage (8% according to the report of Shri Rao and Dr. Sokolov) ; that there are really two blocks in the eastern part, in one of which there is one well only from which it is not possible to obtain any production at present ; that in the other block there are three wells, from which it should be possible to obtain only a very small production of crude oil from the eastern

block of the field was not being taken into account for the purpose of a firm commitment, as it was proposed to use it as a reserve to meet any shortfall that might occur, for one reason or the other, in the oil production rate from the western part of the field.

2.2.9 The Specialists further explained that it was not possible to estimate, at this stage, whether the small increase in the recoverable reserves would make it possible to produce crude oil at an increased rate from this field.

2.2.10 In regard to the Lakwa field, the Specialists explained that there is bottom water in the main pool as well as in the other pools. Water cutting had already started in some of the wells. Water cutting was, therefore, an important consideration for determination of the initial MER per well. The initial MER per well had been fixed on the basis of the productivity index, water cutting, sand cutting, etc., and, as in the case of the Rudrasagar field, the technological scheme for development had been drawn up on the basis of the most economic variant, taking into account the initial MER and after examining several variants of well spacing (i. e. several variants of the number of production wells to be drilled for development of the field). The Specialists showed to the Committee the comparative indices of techno-economic variants, from which it is seen that the return expected to accrue from even the most favourable variant is only marginal. The Specialists explained that any increase in the number of production wells to obtain increased crude oil production rate from the field would be entirely uneconomic.

2.2.11 As regards the dual completion of the wells, the Specialists agreed that dual completion was in principle a desirable and worthwhile proposition, that they themselves were going to experiment with it; but that owing to the various technical difficulties involved in dual completion in this particular field, it was not possible to say, at this stage, to what extent dual completion would be feasible.

2.2.12 The Specialists further explained that as the field is put on production, the oil-water contact in the various pools will go on rising. As a result, in the course of the years, the wells in the outer-most row will first get flooded; also, the oil column in all the wells will become progressively shorter. Consequently, the number of producing oil wells and the oil productivity of the wells will go on decreasing. This process will continue progressively as the oil-water contact rises and more and more rows of the wells get flooded. The crude oil production rate from the field will, therefore, go on declining. When the wells in the outer rows get flooded, one could think of obtaining production from the wells in the inner rows at a greater rate by using a higher draw-down. However, this would not be feasible in the case of this field, as the oil pools have bottom water. Any increase in the draw-down will lead to premature water-coning, which, in turn, will impair the ultimate oil recovery from the field.

2.2.13 The Specialists gave the Committee to understand that, according to accepted practice, plans for development of an oil pool (i. e. for drilling of production wells and obtaining oil production from the pool) can be drawn up only when at least 60% of the recoverable reserves of the pool have been upgraded into 'B' or higher Category. In the case of the Lakwa field, only the main pool, namely Tipam Sand II, fulfils this condition today. The C₁ Category of recoverable reserves in this field are in other pools only, where no 'B' or higher Category reserves exist at present. Consequently, as per accepted practice, even the plans for development of the other pools in this field cannot be drawn up at present. Nevertheless, to maintain a constant production rate (for the reasons explained later) production from the C₁ Category reserves in other pools of the field had also been taken into consideration.

2.2.14 The Specialists further explained that according to the technological schemes for the development of the Rudrasagar and Lakwa oil fields and taking into consideration some production also from the pools in the Lakwa field, the total crude oil production rate from these two fields together could be fairly large—almost as large as that suggested by Shri Rao and Dr. Sokolov—for about three years only but for the reasons given earlier (para 2.2.12) the production rate would be substantially smaller after three years and thereafter the rate would decline progressively. Such a situation would not be satisfactory for purposes of

planning a regular and continuing supply of crude oil at a uniform rate over a number of years. It was in view of this position, according to the Specialists, that it had been decided to produce crude oil at a rate which could be sustained over a period of about 15 years. As it would not be possible to sustain even the planned production rate of 1 million tonnes per year by drawing from the Rudrasagar field and the main pool of the Lakwa field production from the minor pools of the Lakwa field had also been envisaged in the present scheme of things.

2.2.15 The Specialists emphasized that their present estimate of the production rate from the Rudrasagar and Lakwa fields could be revised, only after a substantial volume of additional data pertaining to the performance of the reservoirs in these two fields had been obtained and this would be possible only after the two fields have been put on full production for about 2 years. The Specialists said that at present there would be no basis for modifying their estimate of production rate from these two fields. In this context they also pointed out that due to lack of pipeline facilities for the transportation of the crude oil, it would not be possible to put these fields on full production for the next $2\frac{1}{2}$ —3 years for collection of the necessary data.

2.2.16 Dr. Sokolov, who was present during the meeting with the Specialists, was requested by the Committee to comment on the views expressed by the ONGC Specialists in regard to the increase in the crude oil production rate from Rudrasagar and Lakwa as suggested by him and Shri Rao in their joint report. Dr. Sokolov indicated that their (his and Shri Rao's) estimate of the "average" over a period of 15 years related essentially to the total crude oil that could be produced over the 15 year period, averaged over the 15 years. He expressed the view that the ONGC appeared to have taken a generally cautious view of the expected production rate, and mentioned that in some cases elsewhere the reserves are known to have increased from what they had been estimated originally. He also said that the production rate could be increased by drilling more wells. He made it clear, however, that he could speak only of the technical possibilities and had not taken the economics into consideration. He also said that in the case of Rudrasagar the difference was very minor and could be ignored; and that in the case of Lakwa the approach of the ONGC appeared to be rather cautious.

2.2.17 Dr. Sokolov, however, agreed with the ONGC Specialists that it would not be possible to make an accurate estimate of the production rate until the fields have been put on full production for 2-3 years and the rates of decline of the reservoir pressure and well productivity and the other relevant parameters of the reservoir performance have been determined after sustained production.

2.2.18 After further questioning, Dr. Sokolov agreed that, hypothetically speaking, from oil field having recoverable crude oil reserves of say x million tonnes, a crude oil production rate of $x/15$ million tonnes per year could not be expected to be sustained for a period of 15 years nor could a cumulative crude oil production of x million tonnes be expected during a 15—year period, if the oil-field is developed taking into account techno-economic considerations. He felt, however, that the aforesaid sustained production rate and cumulative production over a 15-year period might be possible, if the reserves are higher, say $4x/3$ million tonnes and in any case not less than $6x/5$ million tonnes.*

2.2.19 On the basis of the oral evidence of the ONGC Specialists and Dr. Sokolov and after careful sifting of all the data presented, the Committee feels that it would not be possible at this stage to forecast categorically the sustained level of production from the Rudrasagar and Lakwa fields together for 15 years as suggested by Shri Rao and Dr. Sokolov, i.e. an additional quantum of 0.5 million tonnes per year over the level estimated by the ONGC. The Committee, however, is of the opinion that the possibility exists of a small increase of about 0.15 million tonnes per year from the two fields together, over the yearly production

* The notations are used by the Committee instead of actual figures. During discussions, Dr. Sokolov used the figures specifically in respect of the ONGC fields, and the proportions are derived from the actuals indicated by Dr. Sokolov.

level envisaged by the ONGC. Nevertheless, since such a small change will not alter the picture for the purpose of the present study, the Committee is of the view that it would be necessary to wait for about 2 years after these two fields have been put on full production, before modifying the estimate of the crude oil production rate made by the ONGC.

2.2.20 In this connection, the Committee also takes note of the concluding paragraph of the report of Shri Rao and Dr. Sokolov which is reproduced below :—

“For sound theoretical calculation for the output of oil from both Rudrasagar and Lakwa fields, it is necessary to obtain data of field studies of reservoirs in the process of trial production for a longer period of time than has been done so far. The behaviour of the outer contour waters, the rate of fall in formation pressure, draw-down, productivity index, variations in G.O.R., and fluid parameters, etc., need to be determined and studied from time to time, for future withdrawal of oil from these fields”.

2.2.21 The Committee is, therefore, of the view that for the purpose of the present study, the estimated crude oil production rates from Assam in the next few years should be the rates based on the estimates of ONGC, OIL and AOC in respect of their respective fields in Assam, although the possibility exists of an increase by about 0.15 million tonnes in the total production rate per year.

2.2.22 In the above context, the Committee notes that at present there are no pipeline facilities for transportation of the Rudrasagar and Lakwa crude oil to the refineries and that these facilities are not likely to be ready for the next 2-3 years. Consequently, not only is the full scale exploitation of these two fields being delayed, but also the acquisition of the valuable reservoir performance data which is essential for estimating the production level from these fields. The Committee, therefore, feels that the construction of the facilities for the transportation of the crude oil should be expedited.

2.3 Capacity of the existing refineries

2.3.1 In terms of the Government Resolution, one of the matters which the Committee is to study and report on is the quantity of crude oil (out of that produced from Assam) that will remain available after meeting fully the requirements of the existing refineries at Digboi, Gauhati and Barauni operating to their optimum design capacities. AOC was requested by the Committee to furnish information on (i) the optimum design capacity of the Digboi Refinery, (ii) the maximum throughput that can be achieved in the Digboi Refinery, with minor modifications and debottlenecking and (iii) the plans of expansion of the Digboi Refinery, if any, within the next 5 years. IOC was requested to furnish similar information pertaining to the Gauhati and Barauni Refineries.

2.3.2 AOC stated that the optimum refining capacity that could be presently sustained by the Digboi Refinery was approximately 0.525 million metric tonnes per year. They also stated that by incurring an expenditure of Rs. 2.84 crores on debottlenecking, the capacity of the refinery could be increased to 0.7 million metric tonnes per year, but that they had presently no firm plans for increasing the capacity of the refinery and that such expansion would depend on (i) adequate crude supplies being assured, (ii) an economic outlet for products and (iii) adequate transportation facilities for product disposal.

2.3.3 IOC informed the Committee that the optimum design capacities of the Gauhati Refinery and the Barauni Refinery were 0.75 million tonnes and 3.0 million tonnes respectively, and that the maximum throughputs that could be achieved with minor modifications and debottlenecking were 0.8 million tonnes in case of the Gauhati refinery and 3.4 million tonnes in the case of the Barauni Refinery. They also stated that while there were no plans for the expansion of the Barauni Refinery beyond 3.4 million tonnes per year, proposals for expansion of the capacity of the Gauhati Refinery to 1 million tonnes per year in 1971 and 1972 and to 1.1 million tonnes per year in 1973 were presently with the Ministry of Petroleum and Chemicals and Mines and Metals. However, subsequently, IOC stated that the Barauni Refinery was capable of still

higher throughput i.e. at 4 million tonnes per year after certain revamping and debottlenecking and, therefore, the figure of 3.4 million tonnes indicated earlier should read as 4.00 million tonnes per year.

2.3.4 The information furnished by AOC and IOC was communicated to the Ministry of Petroleum and Chemicals and Mines and Metals and the Ministry was requested (vide Annexe III) to indicate which figures should be used by the Committee for the optimum design capacities of the three refineries for the purpose of the study envisaged in the Government Resolution. The Ministry has confirmed (vide Annexe IV) that the design capacities of the Gauhati and Barauni Refineries are 0.75 million tonnes per year and 3.00 million tonnes per year respectively. It has also been stated that the Ministry were estimating the actual throughput of the Barauni Refinery at 3.4 million tonnes per year on the presumption that a design capacity of 3 million tonnes would have approximately 10% margin built in its design capacity. It has also been made clear that at present there was no intention of boosting the refinery's capacity to a higher throughput of 4 million tonnes by revamping and debottlenecking and that the question would be examined if the crude oil situation improved.

2.3.5 In regard to the Gauhati Refinery, the Ministry has stated that the refinery had operated at 0.80 million tonnes in the past and that the Government had recently taken a decision to upgrade the capacity to 1.1 million tonnes per year. According to the Ministry, how soon this could be brought into commission was a matter which was now under examination.

2.3.6 In regard to the Digboi Refinery, it has been suggested in the Ministry's reply that the Committee might consult the Second Supplemental Agreement between the Government of India and the AOC, detailing the liability of the OIL to supply from its fields certain stipulated quantities of crude oil to Digboi.

2.3.7 The Committee is of the view that the optimum design capacity of the Digboi Refinery is not determined by the liability of OIL to supply certain quantities of crude oil from its fields to Digboi. Furthermore, AOC have indicated the optimum design capacity of the Digboi Refinery (0.525 million tonnes per year) and the maximum capacity that can be achieved by incurring an expenditure of Rs. 2.84 crores on debottlenecking (0.7 million tonnes per year). It is noted that AOC have presently no firm plans for increasing the capacity of the Digboi Refinery and that the factors on which the expansion would depend are quite uncertain at present.

2.3.8 In view of the position stated above, the Committee assumes that the design capacities of the three refineries and the maximum throughput after minor modifications and debottlenecking which are likely to be achieved in the near future, are as indicated below :—

	<i>Design capacity (million tonnes per year).</i>	<i>Maximum throughput after minor modifications and debottlenecking, which is likely to be achieved in the near future (million tonnes per year).</i>
Digboi Refinery	0.525	0.525
Gauhati Refinery	0.75	1.10
Barauni Refinery	3.00	3.40
Total	4.275	5.025

2.3.9 It is in the light of the above datum that the Committee is required, in relation to the terms of reference given, to assess the surplus of crude oil likely to be available from the fields of ONGC, OIL and

AOC. The estimated crude oil production rates from Assam for the years 1969 to 1979, based on the estimates furnished by these three organisations are given in para 2.2.1 above. It will be noted that the maximum rate reached is 4.1263 million tonnes per year, which is less than the total of the design capacities of the three refineries (4.275 million tonnes per year). Even if the possible 0.15 million tonnes per year increase from the ONGC fields (para 2.2.19) were to be taken into account, the maximum rate would be 4.2763 million tonnes per year only. Furthermore, this production rate is likely to be attained in one year only, the rate coming down thereafter. The availability of the crude oil is thus seen to be no more than the total of the design capacities of the three refineries. The existing refineries ought, therefore, to be in a position, without any modification or debottlenecking, to process the crude oil that can be expected to be produced from Assam, on the basis of the known recoverable reserves in A+B and C₁ Categories. The conclusion inevitably emerges that no new refinery or expansion of any one of the existing refineries would be necessary in the present state of knowledge of the likely availability of crude oil from Assam.

2.3.10 In this context, the Committee further notes that even if one were to take into account the entire additional production rate of 0.50 million tonnes of crude oil per year from Lakwa and Rudrasagar together as envisaged by Shri Rao and Dr. Sokolov, the estimated crude oil production rates per year from Assam would be as indicated below:—

	(million tonnes)*
1971	4.6263
1972	4.6167
1973	4.6060
1974	4.5955
1975	4.1965 (4.5865)
1976	3.7580 (4.5780)
1977	3.3900 (4.5700)
1978	3.0830 (4.2630)
1979	2.8470 (4.0570)

*See note under table in para 2.2.1

2.3.11 It will be seen that the production rates indicated above, though in general higher than the total of the design capacities of the existing refineries, are yet within the total of the maximum throughputs (indicated by the Department of Petroleum) likely to be achieved after minor modifications and debottlenecking of the existing refineries (5.025 million tonnes per year).

2.3.12 It would thus appear that even if crude oil production from the Lakwa and Rudrasagar fields were available at the increased rates envisaged by Shri Rao and Dr. Sokolov, it would be possible for the existing refineries at Digboi, Gauhati and Barauni to process the increased volume of crude oil production from Assam through minor modification and debottlenecking as estimated by Government.

2.3.13 No new refinery or major expansion of any of the existing refineries would, therefore, be required for processing the increased crude oil production from Assam estimated on the basis of the present state of knowledge of the relevant factors. The Committee reiterates the view expressed by Shri Rao and Dr. Sokolov that "it is necessary to obtain data of field studies of reservoirs in the process of trial production for a longer period of time than has been done so far." To this end, the Committee urges Government to ensure that plans for the off take of the full production potential of the ONGC fields as currently estimated by ONGC are expedited.

CHAPTER III

3.0 Processing Schemes and Refining Costs.

3.1 It has been stated in Chapter-II that, as presently foreseen, the estimated level of annual production of crude oil from Assam will be sufficient only to meet the programmed requirements of the refineries at Digboi (0.5 million tonnes per year), Gauhati (1.1 million tonnes per year) and Barauni (3.4 million tonnes per year). In other words, even at the presently estimated maximum level of crude oil production, the available crude oil will only go to meet the requirements of the existing refineries and there would not be surplus crude oil available from Assam for creating additional refining capacity.

3.2 Assuming, however, that some time in the future new crude oil reserves are found in Assam and additional quantities can be produced to warrant the establishment of additional refining capacity in Assam three alternative sites have been studied. These are :—

- A Refinery at the oil field (Gelcki-Nazira as an example).
- B Expansion of Gauhati Refinery.
- C Dhubri which lies to the north of the Brahmaputra at its westernmost point in Assam before it turns into Pakistan. The purpose of choosing Dhubri is to find the economics of locating a refinery as much westward as possible in Assam so that the product movement cost can be reduced.

3.3 For each location four cases with straight distillation and additional units have been studied as below :—

Case Ia. 1 MM t/y refinery with kerosene treatment, without coker.

Case Ib. 1 MM t/y refinery with kerosene treatment and with coker.

Case IIa. 2 MM t/y refinery with kerosene treatment without coker.

Case IIb. 2 MM t/y refinery with kerosene treatment with coker.

3.4 Market demand estimates have shown that a very substantial part of the production from the additional refining capacity indicated above will have to be moved out of Assam to markets in the West Bengal, Bihar, Uttar Pradesh and Delhi. Consequently, it was felt necessary to compare the refining costs at locations A, B and C above, with the cost involved in refinery locations outside Assam nearer the areas of consumption for processing the surplus crude oil from Assam. The locations assumed outside Assam are :—

D Barauni (Expansion)

E Kanpur

3.5 Processing Schemes

3.5.1 Assam crude oils are aromatic in nature and yield on distillation :

- 1 Naphtha which with the addition of TEL can meet the ISI specifications for motor gasoline,

- .2 Kerosene fraction which requires improvement of smoke point,
- .3 Diesel oil fraction which can be marketed directly after some additive treatment,
- .4 Residue with low sulphur content and high pour point, which cannot be transported easily.

3.5.2 Hence the following two schemes were selected :

- .1 With straight distillation and kerosene treatment with necessary finishing units for the main products ;
- .2 With coker with necessary units to separate coker products, in addition to straight distillation and kerosene treatment and finishing units.

3.6 Investment

3.6.1 The following four alternative schemes for each location ; on the basis of the processing units and their capacities, have been considered for estimating investments on the assumption that in the absence of any data on the characteristics of crude oil from new finds, these would be similar to those of the Lakwa-Rudrasagar crude mix :

Case Ia) : 1 mtpa refinery with a topping unit and kerosene treating unit (KTU)

	Estimated Capacity (tonnes/year)
Distillation Unit	1 million
KTU	150,000

Case Ib) : 1 mtpa refinery with a topping unit, KTU a coker

Distillation Unit	1 million
KTU	150,000
Coker	300,000

Case IIa) : 2 mtpa refinery with a topping unit and KTU

Distillation Unit	2 millions
KTU	300,000

Case IIb) : 2 mtpa refinery with KTU and a coker

Distillation Unit	2 millions
KTU	300,000
Coker	600,000

3.6.2 The production patterns for these processing schemes are shown in Annexe V.

3.6.3 The total investment for each case comprises onsite and offsite plant costs. The offsite investment for a grass roots refinery at locations A, C and E is taken as 100 per cent of onsite cost. The onsite costs have been calculated on the basis of the units actually required for each case. The offsite cost for Gauhati (Case B) is assumed to be 80 per cent of the onsite investment and for Barauni (Case D) 50 per cent due to the fact that expansion at Gauhati would need more facilities compared to the bigger Barauni refinery. Also the space available with the existing refinery at Gauhati is limited and expansion would therefore cost more.

3.7 Investment and Refining Costs

3.7.1 The total onsite and offsite investment costs are summarised in Table III.1.

TABLE III.1—Total Investment Costs
(In Rs. Million)

Case	A	B	C	D	E
Ia.	66.0	57.5	64.8	46.8	63.0
Ib.	132.0	118.0	129.6	93.6	126.0
IIa.	110.0	98.4	108.0	78.0	105.0
IIb.	211.0	189.0	207.0	149.7	201.6

3.7.2 For purposes of estimating refining costs, 22 per cent of the investment is taken as the fixed cost including maintenance, insurance, overheads, depreciation, interest, etc. The total processing costs including utilities and fixed costs are given in Table III.2.

TABLE III.2—Total Processing Costs
(In Rs. Million/Yr.)

Case	A	B	C	D	E
Ia.	17.4	15.5	17.2	13.2	16.8
Ib.	36.2	33.2	35.7	27.8	34.9
IIa.	30.0	27.4	29.6	22.9	28.9
IIb.	60.8	56.0	59.6	47.3	58.6

3.7.3 The refining costs per tonne of crude oil processed are summarised in Table III. 3.

TABLE III. 3—Refining Costs
(Rs./Tonne)

Case	A	B	C	D	E
Ia.	17.4	15.5	17.2	13.2	16.8
Ib.	36.2	33.2	35.7	27.8	34.9
IIa.	15.0	13.7	14.8	11.45	14.45
IIb.	30.4	28.0	29.95	23.65	29.3

*Excluding the cost of crude oil.

3.8 It will be seen that the investment for a grass roots refinery in Assam (Cases A and C) is more than for a similar refinery outside Assam (Case E) because of higher cost of transportation of the plant to Assam from the nearest port. In the case of Kanpur (Case E) the plant is assumed to be transported from Kandla whereas in the other alternatives the plant is assumed to be transported from Calcutta. Expansion of Gauhati and Barauni Refineries (Cases B & D) will require lower investment.

3.9 Table III. 3 on refining costs shows that the refinery location at the oilfield (Case A) would involve maximum refining cost per tonne of crude oil. This is mainly because of the higher fixed cost component in this case.

3.10 In the event of the characteristics of the new crude oil finds from Assam being such that the products from the above-mentioned processing schemes do not meet the market specifications, more sophisticated technology may have to be employed, which will increase investment and refining costs.

CHAPTER IV

4.0 Demand for Petroleum Products within the State of Assam existing and in future ; areas of economic distribution for marketing additional production ; and comparative cost of transportation of crude oil and petroleum products pertaining to different locations for additional refining capacity.

4.1 On the assumption that sufficient crude oil becomes available at a future date to render it feasible to create additional refining capacity, the question would arise whether the establishment of such additional capacity would be justified on grounds of additional demand, the economics of refining and the over-all economics of transportation of crude oil and petroleum products. These questions are examined in detail in the following paragraphs.

4.2 Period chosen for forecasts :

4.2.1 While considering the economics and the viability of additional refining capacity for the future, it would be reasonable to consider as long a period as possible. A projection made for the next twenty years would, for example, be ideal. However, considering that the oil industry in India is very young and indigenous production of oil and refined products has started in a substantial measure in India only during the last decade or so, and considering that the likely pace of economic and industrial progress in the country during the next few Five Year Plans cannot be predicted with reasonable accuracy, it would be difficult to make realistic projections of demand and supply for a period of twenty years, particularly in terms of regional growth of consumption which is a vital factor for planning additional refining capacities. Keeping this in view, the Committee has made detailed projections of supply and demand and movement patterns for the period upto 1975 and a general projection of trends till 1980. These projections are considered adequate for coming to conclusions about the trends in the future as a basis for present decisions.

4.3 Demand in north-east area :

4.3.1 The refineries at Gauhati and Digboi supply products not only to the State of Assam but also to the neighbouring areas of Tripura, Manipur, NEFA, Bhutan and Sikkim. At present a sizeable part of the production from these refineries is moved to areas much further away like the Southern region of West Bengal, Western U. P. and even to Punjab and Haryana. The movement of petroleum products to various areas in the country from alternative sources of supply is decided on a consideration of several factors like the availability of product pipelines and their operating requirements, directional flow of rail traffic determined by operational convenience, availability of rail tank-wagons and ancillary facilities, over-all transportation economics and the need to keep all areas adequately supplied with products at all times. Based on these considerations, Assam and the north-eastern regions of Nagaland, Manipur, Tripura, NEFA, Bhutan and Sikkim and the adjacent northern and eastern areas of West Bengal, form a logical area to which the products manufactured in the refineries in Assam could move with advantage. Accordingly, the demand of the over-all north-east area has been computed and projected for future years by taking into account the demand for various products in the areas indicated above. The map placed at Annexure VI shows the location of the Digboi and Gauhati refineries and the logical area which can be fed from these refineries.

4.3.2 Annexure VII shows the actual consumption of the various petroleum products in this area in the year 1968, split up into various convenient consumption regions. The total demand for all the major petroleum products including Bitumen in this area was 0.64 million tonnes during the year 1968 as against the total combined production of 1.21 million tonnes of products (against a crude oil throughput of 1.34 million tonnes) from the Digboi and Gauhati refineries. The balance of 0.57 million tonnes of petroleum products was moved to farther areas in the southern part of West Bengal, Western Uttar Pradesh, Punjab, Orissa and Haryana.

4.3.3 Annexure VIII shows details of the demand for the major petroleum products in the north-east area for the years 1969-75. Based on these trends, the likely demand in 1980 has also been shown. The rate of growth of demand in this area has been based on the best estimates available with the industry. During the period from 1963 to 1968, the demand for petroleum products in the north-east area has increased at an average growth rate of 5.4% compound per annum. The Committee considers that the anticipated annual growth rate of 7.9% for the period 1969-1975 and 8.9% for the period 1976-1980 is reasonable, in as much as it makes due allowance for more rapid industrialisation and general development of this area visualised in the future. The yearly and compounded growth rates have been shown in Annexe IX.

4.3.4 Accordingly, the total consumption of the major petroleum products in this area is expected to reach a level of 1.09 million tonnes during 1975 and a level of 1.66 million tonnes during 1980. This level of consumption in this area by 1980 compares with the total production of 1.6 million tonnes of all products from the Digboi and Gauhati refineries. It will thus be seen that the total production of these two refineries at the presently visualised levels, will be sufficient to meet the needs of Assam and the adjoining north-eastern areas for several years to come and a sizeable part of the production of these refineries will, in fact, have to be moved for many years to areas outside the aforesaid area.

4.3.5 While this position emerges when we take the total consumption of all the major petroleum products as a whole, there are expected to be some variations when each product is considered separately. Whereas the production from the existing refineries in Assam will be sufficient to meet the needs of this area for almost all the products, the availability of kerosene would fall short of the total demand of the area in the coming years. The extent of shortfall would be about 0.15 million tonnes by 1974 and 0.18 million tonnes by 1975. This isolated case of deficit of one product would not by itself justify the setting up of additional refining capacity in that area, as this will result in the production of other products in quantities larger than can be absorbed within that area. It is relevant to note in this connection that kerosene production will be only about 15% of the crude oil processed. Also, the deficit of kerosene in the area would only be a reflection of an all-India deficit of this product, to be met by imports until the coming up of additional refining capacity and the gradual rectification of the imbalance between demand and production.

4.3.6 The question of setting up additional refining capacity in Assam is to be considered in the context of the fact that the present/programmed production from the refineries in Assam is sufficient and will continue to be sufficient to meet the total demand of this area (other than for kerosene) for several years. In fact, this general pattern obtains even in a larger context, when we consider the entire eastern region of India. The combined production from the refineries at Digboi, Gauhati, Barauni and Haldia in the eastern region of India, as shown in Annexe V, would be sufficient to meet the entire demand in eastern India and a substantial part of this production will have to move to areas west of Kanpur. Thus any additional refining capacity established in Assam or elsewhere in eastern India would have the effect of displacing a corresponding quantity of petroleum products out of this region to destinations which would be further west of Kanpur. This location of additional refining capacity in the eastward direction will, however, result in the transportation of crude oil over comparatively shorter distances. Therefore, to the extent the location of additional refining capacity is made farther east in this region, the cost of movement of products westward would tend to increase, and the cost of crude oil transportation would tend to decrease. The details of such costs and the comparative advantages and disadvantages of locating the additional refining capacity at various alternative locations are discussed in greater details below.

4.4 Transport Costs

4.4.1 The Committee has considered the over-all comparative costs of transportation in locating additional refining capacity at alternative locations, namely, Geleki-Nazira, Gauhati, Dhubri, Barauni and Kanpur, as mentioned in Chapter III, with reference to two major items of cost (besides the refining costs which have been considered in Chapter III) :—

- (a) Cost of transportation of crude oil ; and

(b) cost of transportation of petroleum products to the destinations where the products will be consumed. (This will include the cost of movement by rail and by pipeline).

4.5 Cost of transportation of Crude :

4.5.1 In computing the cost of transportation of crude oil, the Committee has taken into account the following distances from Geleki/Nazira area to the alternative locations for additional refining capacity :

Geleki-Nazira	...	Nil
Gauhati	...	366 Km.
Dhubri	...	610 Km.
Barauni	...	1102 Km.
Kanpur	...	1772 Km.

4.5.2 The Committee has assumed that the most economic method of transporting crude oil from the oil fields to these locations would be pipeline. This is, in fact, presently adopted almost exclusively for the transportation of crude oil from the oil-fields in Assam to Gauhati and Barauni. In working out the comparative costs and advantages of different locations, the Committee has examined the economics of transporting crude oil through a new pipeline, and the feasibility and economics of utilising the existing pipeline of OIL (after suitable additions and modifications) after meeting the requirements of Gauhati and Barauni refineries at 1.1 and 3.4 million tonnes/year respectively.

4.5.3 Annexe X-A gives the investments on crude oil pipeline including ancillary facilities and comparative costs per tonne of transportation of crude oil to the various locations at 1 million/2 million tonnes throughout.

4.5.4 From the data presented in Annexe X-A it is seen that for transporting 1 million tonnes per annum of additional crude oil it is comparatively economical to increase the capacity of the existing pipeline of OIL. For transporting 2 million tonnes per annum of additional crude oil the economics of building a new pipeline is more or less comparable to that of increasing the capacity of the existing pipeline of OIL. But in the latter case the capacity gets stretched to the maximum extent so as not to permit any further expansion, and the former alternative has therefore been adopted.

4.6 Cost of Distribution of products :

4.6.1 As indicated earlier, the additional products (other than Kerosene) available from any new refinery in this area would be surplus to the needs of the eastern region. This additional output would either have to move outside the region or displace an equivalent quantity which would have to move to destinations west of Kanpur. In this context, the additional production of any refinery and its transportation would have to be suitably dovetailed into the existing movement pattern of over 8 million tonnes of products from the existing/programmed refineries in the eastern region (Digboi 0.5, Gauhati 1.1, Barauni 3.4 and Haldia 3.5 million tonnes per year) so as to achieve not only an integrated movement pattern, but also to avoid any seriously adverse impact on the economics of movement of products of the existing/programmed refineries. Annexe X-B gives the investments on new white oil product pipelines and the unit Costs of transportation for the various alternatives. Keeping these in view, the best possible movement pattern for the products to be obtained from the additional refining capacity at various locations has been worked out and the details are shown in the tables at Annexes XI-A to XI-G. A summary of the total costs of movement of crude oil to each location of additional refining capacity and of the products from each location is given in Annexe XII. This Annexe also gives the total quantum of rail movement of products from different locations in terms of millions of tonne-kilometres. The latter would give an idea of the extent of the major additional capital intensive facilities like tank wagons, locomotives, rail sidings and related additional facilities which will be required to be developed by the Railways to handle the additional traffic.

4.6.2 The detailed break-up of the comparative costs of transportation of crude oil and of refined products for the various alternative locations, for additional capacities of 1 and 2 million tonnes per annum, is given in Annexe XIII-A to XIII-E.

4.6.3 Summarising the results, it will be observed that :—

- (a) the farther east the refinery, the higher is the over-all cost of transportation ;
- (b) optimum economy on a product pipeline can be achieved only in the case of a 2 million tonnes refinery ; and
- (c) the maximum saving in transportation cost would arise only in the case of product pipeline (white oils) connected to Delhi.

4.6.4 While Annexe XII gives the details of comparative cost of transportation in relation to each refinery location, the overall cost of transportation in respect of a one and two million tonne refinery (with Coker) under alternative assumptions is summarised below :—

		(in lakhs of rupees)				
	Geleki/Nazira	Gauhati	Dhubri	Barauni	Kanpur	
Case—A Total transportation cost of crude oil by PL and products by rail.	Ib 1169	1219	1335	1152	1094	
	Iib 2336	2324	2372	2057	1667	
Case—B Crude oil transportation by pipe line and product transportation by pipeline to Siliguri and thence by rail	Ib 1258	1233	1348	1152	1094	
	Iib 2180	2197	2291	2057	1667	
Case—C Crude oil transportation by pipeline and product transportation by pipeline to Barauni and thence by rail.	Ib 1248	1204	1319	1152	1094	
	Iib 2052	2057	2139	2057	1667	
Case—D Crude oil transportation by pipeline and product transportation by pipeline to Kanpur and thence by rail.	Ib 1282	1194	1314	1148	1094	
	Iib 1914	1926	2079	1810	1667	
Case—E Crude oil transportation by pipeline and product transportation by pipeline to Delhi and thence by rail.	Ib 1255	1134	1238	1120	1033	
	Iib 1719	1728	1843	1674	1475	

4.6.5 In arriving at the above estimates of overall cost of transportation, it has been assumed that the movement of finished product by pipeline will be confined to white products only. Black oil, viz., furnace oil it has been assumed, will move direct by rail from each location. The above assumption is based on the consideration, first, that furnace oil and white products cannot be transported through the same pipeline and, secondly, that the production of furnace oil at 1 and 2 million tonnes crude oil throughput would be only 60,000 and 1,20,000 tonnes respectively, which would not justify laying a separate pipeline.

4.6.6 The above transportation costs also include the transport cost of coke expected to be produced from the additional refining capacity. The estimated production of green coke at 1 and 2 million tonne

throughput will be 36,000 and 72,000 tonnes respectively. The bulk of the coke production could be absorbed by the aluminium industry. Annexe XI-G shows the rated capacity of the existing/proposed aluminium plants in the northern and eastern regions and their annual requirement of coke. The coke requirement has been indicated in terms of calcined coke. Taking the equivalent calcined coke availability from the existing refineries at Gauhati, Barauni and Digboi and the requirement of the aluminium industry in this region, it is assumed that the additional coke production from the new capacities of one and two million tonnes would need to be ultimately absorbed by the aluminium plants at Renukoot and Korba. The transportation cost of coke on the basis of moving calcined coke from the new refinery to the above two locations of consumption has been included in the overall cost of transportation given above. In the event calcination of green coke is not possible/permitted at the new refinery and the green coke is to be calcined at the respective locations of consumption, the transportation cost of green coke will increase by about 33 1/3 % in respect of supplies from each location.

4.6.7 As compared to the cost incidence of transportation in respect of a 2-million tonne refinery as indicated above, the transportation cost in respect of a 1-million tonne refinery shows a smaller variation for the various alternative locations. It is, however, seen from Annexe XII that the unit cost of transportation tends to go down with a larger refining capacity resulting in larger pipeline throughput. Also, as brought out in para 3.7.3, the unit cost of refining is lower in the case of a 2 million tonne refinery than for a 1 million tonne refinery.

4.6.8 Annexe XII also highlights the magnitude of the traffic load on rail-road system (in terms of million tonne-kilometres) relative to each location. For a refinery of 1 and 2 million tonne capacity (with coker), the traffic to be handled by rail under various alternative cases will be of the following magnitude :

			(in million tonne-KMs)				
			Galeki/ Nazira	Gauhati	Dhubri	Barauni	Kanpur
(a)	With no product Ib pipeline ; all movement by rail.	Ib	1848	1501	1394	904	344
		I Ib	3752	3057	2817	1766	696
(b)	With product pipeline upto Siliguri	Ib	1371	1279	1245	904*	344*
		I Ib	2758	2566	2487	1766*	696*
(c)	With product pipeline upto Barauni	Ib	1185	1093	1059	904*	344*
		I Ib	2364	2172	2093	1766*	696*
(d)	With product pipeline upto Kanpur	Ib	868	776	742	522	344*
		I Ib	1775	1583	1504	1044	696*
(e)	With product pipeline upto Delhi	Ib	655	563	529	309	130
		I Ib	1398	1206	1127	658	316

*Movement direct by rail as corresponding product pipeline case not applicable.

4.6.9 It will be seen from the above that the investments on tankwagons, locomotives, other ancillary facilities would increase substantially as locations are assumed in the eastward direction. The impact on

track capacity (of the additional tonne-kilometres involved) would also need to be reckoned. The investments on these facilities will have a bearing on the decision as to the most suitable and economic location for positioning additional refining capacity based on Assam crude oil.

4.6.10 It may be mentioned that the cost comparisons made between different alternative locations are on the basis of railway freight rates and the cost of transportation by pipeline. However, the costs of movement of items like POL products by rail are known to be lower than the Railway freight rates. There is thus an element of bias against alternatives involving rail movement of products. This Committee does not have estimates of Railway costs. To the extent that there is likely to be a difference between Railway freight rates and costs of rail haulage, the disadvantage on account of overall transportation costs to eastern locations as compared to western locations will be reduced.



CHAPTER V

5.0 Total cost of refining and transportation of crude oil and petroleum products

5.1 The aggregate of the refining costs and the costs of transportation of crude oil and petroleum products in the various alternatives is shown in the following table :—

Total cost of transportation of crude oil and products and cost of refining
(Rs. in Lakhs)

Product line upto	Refining Scheme	Refinery Location				
		Galeki	Gauhati	Dhubri	Barauni —	Kanpur
Galeki	Ia	1358	1364	1490	1244	1152
	Ib	1531	1551	1692	1430	1443
	IIa	2700	2621	2881	2260	1791
	IIb	2944	2884	2968	2530	2253
Siliguri	Ia	1530	1414	1558	1244	1152
	Ib	1620	1565	1705	1430	1443
	IIa	2701	2586	2661	2260	1791
	IIb	2788	2757	2887	2530	2253
Barauni	Ia	1564	1419	1632	1244	1152
	Ib	1610	1536	1676	1430	1443
	IIa	2657	2523	2591	2260	1791
	IIb	2660	2617	2735	2530	2253
Kanpur	Ia	1691	1479	1595	1328	1152
	Ib	1644	1526	1671	1426	1443
	IIa	2673	2487	2562	2173	1791
	IIb	2522	2486	2275	2283	2253
Delhi	Ia	1745	1476	1586	1373	1156
	Ib	1617	1466	1595	1398	1382
	IIa	2530	2376	2474	2121	1697
	IIb	2327	2288	2439	2147	2061

5.2 It is seen that in view of mainly of long haulages involved in the transportation of crude oil and/or petroleum products, the unit costs even in the most economic alternative are very high—being in most cases higher than the landed price of crude oil.

5.3 It is also relevant to note that while locating any additional refining capacity based on Assam crude oil far to the west would be of advantage from the point of view of minimizing the over all cost of transportation of crude oil and refined products, the cost of transportation of crude oil may be so high that the supply thereof may become entirely uneconomic to the producer of crude oil.

CHAPTER VI

6.0 Possibilities of producing Aromatics and Ammonia from Assam crude oil.

6.1 In terms of the minute dated 2.7.1969 recorded by the Minister, Petroleum & Chemicals and Mines & Metals (Annexe XIV), the Committee has studied the possibilities of establishing other industries based on crude oil, particularly for products such as aromatics and liquid ammonia and transporting them to other parts of the country for further processing and use. The possibilities of producing aromatics and ammonia in Assam are discussed below.

6.2 Production of Aromatics

6.2.1 The crude oils of the Assam region are generally richer in aromatics than, for example, the Gujarat crudes and they are potential sources of producing simpler aromatics. The fractions of the crude oil suitable for production of aromatics are : 60°—85° C cut for benzene, 85°—110° C cut for toluene and 120°—145° C cut for xylenes. It is assumed, in the absence of a sample, that additional crude oil likely to be available from the Galeki—Nazira fields will be similar to the Lakwa—Rudrasagar (L—R) Mix. Of the Assam Crude oils, the Nahorkatiya crude is better than the L—R mix for the production of aromatics from the view point of yields of the desired fractions. In the absence of data on detailed chemical composition of naphtha cuts from L—R mix, an approximate estimate has been made of the possible yields on aromatics.

6.2.2 In the following discussion, two possibilities of processing have been considered :

- 1 Naphtha from 2 million tonnes new crude (from Galeki—Nazira field to be used for production of aromatics.
- 2 Naphtha from 1 million tonnes new crude and naphtha from 1.1 million tonnes Nahorkatiya (NHK) crude at Gauhati Refinery to be pooled and processed for production of aromatics.

6.3 Aromatics from 2 million tonnes new crude

6.3.1 Two alternative processing schemes may be considered as discussed below :

- 1 Processing the crude in a conventional refinery to produce fuel products and coke: This involves crude oil distillation, separation and fractionation of naphtha cuts, production of kerosene, diesel oil, coke, fuel oil and LSHS as in Scheme IIb in Chapter III. The net yield of naphtha of 60°—145° C range would be 110,000 tonnes from which benzene and xylenes would be produced. The yields of aromatics are summarised in Table VI.I at the end of this Chapter. In this case, all the products other than naphtha have to be transported out of Assam as discussed in Chapter IV.
- 2 Distillation of the crude to produce naphtha and kerosene and use the long residue for ammonia production and captive power generation: The yield of naphtha would again be 110,000 tonnes and the yields of aromatics are similar to the case above. Only one simple distillation unit and naphtha splitter are required in addition to aromatics plant. Provision could be made for production of diesel oil depending upon the demand in Assam.

6.4 Aromatics from 1.1 million tonnes NHK/crude and 1 million tonnes new crude

6.4.1 In this case, the naphtha (60°—145° C) from the Gauhati refinery processing NHK crude is separated from the total naphtha fraction after meeting the local demand for motor gasoline. The remaining naphtha (60°—145° C) thus available from aromatics would be 50,000 tonnes. Additionally, one million tonnes of new crude are distilled to separate the naphtha cut (55,000 tonnes) and kerosene and long residue above

250° C. The total of 105,000 tonnes of naphtha cut is processed to produce aromatics whose yields are summarised in Table VI. I.

6.5 In all the above cases, the aromatics plants include catalytic reformer, fractionation of reformates, extraction of aromatics, toluene dealkylation, isomerisation of metaxylene, crystallization and separation of p-xylene, DMT unit and benzene hydrogenation to cyclohexane. It would be desirable to include a polyester spinning plant to produce the fibre which fetches a higher price. The cyclohexane has a good export market and can bear cost of transport to a port. It is also feasible to establish a plant to produce 15—20,000 tonnes of nylon leaving the rest of the cyclohexane for export. In any case, it appears desirable to include in the aromatics project the production of large quantities of benzene and its hydrogenation or cyclohexane. The demand for aromatics in the Assam region is presently quite low. The demand for benzene in the north-eastern and northern India and West Bengal is estimated to be about 43,000 tonnes in 1975 and the production is likely to be less than 30,000 tonnes. It is, therefore, possible to transport benzene to meet the demand in this region outside Assam. However, this has to be transported by rail tank wagons and this could involve transshipment from meter gauge to broad gauge. This, apart from increasing the cost of transportation, would endanger the purity of the product which has to be very high for use in the chemical industry. Conversion of the Railway system in this area to the broad gauge would obviate this problem. While such a step would also help the industrialization of Assam, the Committee feels that this subject is beyond its competence and terms of reference, but which deserves careful consideration in the light of all relevant factors.

6.6 Since transportation of petroleum products out of Assam is likely to render the project uneconomic due to excessive transportation costs, other possibilities may be considered as below :

1. Combination of aromatics production from naphtha cut and large scale ammonia production from the topped crude using partial oxidation processes.
2. Combination of production of aromatics and highly aromatic industrial solvents with large-scale ammonia production from the remaining crude. It may be noted that the high aromatic content of Assam crudes is likely to prove advantageous in the production of aromatic solvents which have a good market.

The combination of aromatics and ammonia production is feasible for the Schemes 2 and 3 shown in Table VI.I, using the long residues for the production of ammonia by the partial oxidation process.

6.7 Production of Olefines

6.7.1 Production of aromatics and ammonia discussed above can be integrated with that ethylene and higher gaseous olefines. Stream cracking of naphtha is widely used for production of olefines and other petrochemicals. In recent years, newer processes have been developed for production of olefines by cracking of heavier hydrocarbons and even the whole crude oil. Recovery of pure aromatics from cracked products is an established technology. The stocks left after extraction of aromatics and olefines from the cracker products can form a useful feedstock for production of ammonia by the partial oxidation process.

6.7.2 These petrochemical processes offer scope for integrating the production of aromatics, ammonia and petrochemicals and for the installation of an economically viable complex in Assam. It should however be appreciated that the main market for most of the products from such a complex is outside Assam and hence an integrated development of fertiliser/petrochemical industry in Assam, West Bengal, Bihar and Uttar Pradesh would be essential.

6.8 Production of Ammonia

6.8.1 The case for the establishment of additional refining capacity in Assam based on Assam crudes rests essentially on the concept that the only way to develop an industry based on crude oil is to refine it.

While this is generally true, in recent years processes for direct conversion of crude oil into chemicals are being seriously considered as viable. It is, therefore, possible to consider ways of starting basic industries other than by refining, with a view to use crude oil produced in the state. For example, the following possibilities of massive production of ammonia based on natural gas and crude oil could be considered :

- .1 Making maximum use of natural gas which is the best and cheapest source for ammonia production. In addition to the existing plant at Namrup, the expansion scheme is also based on use of natural gas. If possible, the 10 m.c.f.d. allocated to Assam Gas Co. and the 18 m. c. f. d. allocated to the Assam Electricity Board may be diverted for production of Ammonia. The fuel needs for power generation may be met as far as possible by using residual fuels. If the latter cannot be used for technical reasons in existing power plants, the residual fuel has to be diverted to ammonia production.
- .2 Using crude oil as such in the partial oxidation processes to produce ammonia.
- .3 Topping of crude oil and separation of naphtha ; conversion of naphtha into synthesis gas by steam reforming process depending upon the quality of naphtha and converting the remaining "long residue" by the partial oxidation processes into ammonia.

6.8.2 These alternatives are attractive in the special circumstances of the Assam State. The implications of the large scale manufacture of ammonia from crude oil in Assam are the following :

- .1 The entire ammonia has to be converted into sulphate, nitrate or urea and transported out of the State in view of the limited demand within.
- .2 Alternatively the recently developed technology of transport of liquid ammonia by pipeline which is gaining rapid acceptance on a large scale in the United States, can be adopted to transport ammonia outside Assam into the North Bihar and UP regions where the Gangetic basin can absorb very large quantities of fertilizer. It may be noted that the nitrogen demand in 1973-74 in the Assam, Nagaland, Manipur, NEFA, Tripura, Bihar and Uttar Pradesh regions is about 1.03 million tonnes. As against this, the anticipated production in 1973 from all the fertiliser plants in the northern India and eastern regions (Gorakhpur, Kanpur, Barauni, Mirzapur and Namrup plants) would total to about 720,000 tonnes. Thus there appears to be a gap of 300,000 tonnes of nitrogen by 1973-74. In view of the increasing emphasis placed on agricultural production and the consequential need for fertilizers, the gap between likely demand and the availability of fertilizer could well be greater. It therefore appears desirable to undertake manufacture of Ammonia in Assam based on surplus crude oil that is likely to be available there. If large capacity plants are located near the oil fields the cost of production would be considerably lower.

6.8.3 Five reprints describing the latest experience and efforts on transportation of liquid ammonia for long distances in pipelines are enclosed (Annexe XV). If it is found feasible to import liquid ammonia in refrigerated tankers across high seas to coastal locations in India and convert it into fertiliser salts in coastal plants, there would also appear to be possibility of economic transportation of liquid ammonia by pipeline from Assam into northern India (Bihar, Uttar Pradesh regions) and convert it into ammonium salts in plants located in north India. The Committee feels that this alternative deserves careful study. Such a project would not only help to solve the problem of supply of feed stocks for fertiliser manufacture in India which has engaged much attention in recent years, but also help to establish heavy and labour intensive industries in Assam based on crude oil processing. It is however essential to appreciate that refining for production of fuels need not be the only method of developing an industry based on crude oil.

6.9 The proposed refinery-cum-chemical complex can be established only when additional crude oil finds become available from Assam over and above 5.025 mtpa which can be utilised in the refineries at Digboi,

Gauhati and Barauni at their optimum capacities. On present knowledge it seems unlikely that crude oil production over and above 5.025 mtpa will become available in Assam in the foreseeable future. There is however a possibility which might result in a certain surplus quantity of crude oil becoming available in Assam somewhat earlier for a chemical complex of the type proposed in this chapter. This possibility and the problems involved are briefly examined below.

6.9.1 A major desideratum in planning for the use of the crude oil available in Assam is the type of crude oil likely to be available in the future from the newer fields discovered recently. As indicated earlier there is at present no information on the chemical properties of the crude oil likely to be available from the Galeki-Nazira fields. For working purposes, it has been assumed that the new oil would be of the Lakwa-Rudrasagar type, the properties of which are somewhat different from the Nahorkatiya crude. If, it should transpire that the crude oil reserves in the Galeki-Nazira fields or the Lakwa-Rudrasagar fields cannot be processed economically or satisfactorily at Barauni (with special reference to its lube oil plant), it would then be necessary to study in detail the economics of use of this crude oil for new ways of setting up industries based on crude oil on the lines indicated earlier, and supplementing the crude oil available for Barauni from the Nahorkatiya and Moran fields by planning for import of Sweet crude oil for efficient operation of the Barauni lube plant.

6.9.2 In the absence of conclusive evidence at this stage, this Committee has been handicapped in coming to a final judgment in this connection. Should further investigations prove what is stated above, and should the economics of the alternatives proposed be found to be favourable, namely, to divert in the long run the new crude from Assam for production of aromatics, fertilisers and other chemicals, and to meet the gap between the capacities of the existing refineries and the availability of Nahorkatiya type crudes from Assam by import, two conclusions would follow. First, this situation would release adequate Assam crude for starting a new chemical complex in Assam, and secondly, it would obviate the difficulties of economic production of lubricating oils and other key products of satisfactory quality from the newer Assam crudes at Barauni. This latter problem will be accentuated as the production of Nahorkatiya crude oil decreases in future but will diminish if the newer finds prove to be as good as or better than Nahorkatiya crude.

6.9.3 A decision on this will however depend on the economics of (i) the availability of sweet crude oils in the world market at reasonable prices, (ii) the additional investments involved in making necessary modifications at Barauni to enable processing of high sulphur imported crude oils, and (iii) the utilisation of the Haldia-Barauni Pipeline for transportation of crude oil and the consequent transportation of white products from the Haldia refinery by rail.

6.9.4 If the overall economics of the aforesaid factors justify the importation of crude oil of the order of 1.4 mtpa for processing it at Barauni, it would be possible to create a surplus in Assam to the extent of 0.5 to 1.0 mtpa even with the normal production of 4.1 mtpa or the maximum production of 4.6 mtpa of crude oil in the Assam area for establishing a chemical complex.

6.10 This Committee is not in a position to go in detail into these basic problems nor are they within the terms of reference of this Committee. The time available to this Committee is also too short to make a detailed techno-economic study of the proposals in the foregoing paras for production of aromatics and large quantities of ammonia. Detailed techno-economic studies by a separate technical group would be necessary to establish the relative merits of the various alternatives indicated in this Chapter.

TABLE VI.1

Yields of Aromatics (tonnes)

<i>Scheme</i>	<i>1</i>	<i>2</i>	<i>3</i>
<i>Product yields</i>	<i>2 MMT conventional refinery + Coker (Ref. para 6.3.1.1)</i>	<i>2 MMT simple distillation (Ref. para 6.3.1.2)</i>	<i>1.1 MMT NHK crude and 1.0 MMT new crude. (Ref. para 6.4.1)</i>
1. <i>Naptha</i>	110,000	110,000	105,000
2. <i>Aromatics from Naptha</i> (1)			
Benzene	37,000	37,000	58,000
P-xylene	17,000	17,000	18,000
O-xylene	5,000	5,000	5,000
3. <i>Products from Aromatics</i>			
Cyclohexane	40,000	40,000	63,000
DMT	24,000	24,000	25,000
4. <i>Other products</i>			<i>From one MMT (2) new crude</i>
Kerosene	244,000	244,000	127,000
Diesel Oil	530,000	530,000	—
Long residue	—	1,028,000	782,000
Gas, fuel oils, coke, etc,	1,028,000	—	—
5. <i>Investment (Rs. Crores, approx.)</i>			
(a) Crude oil distillation and naphtha splitting	21	8	55
(b) Aromatics plant (3)	30	30	35

(1) Benzene includes that from toluene dealkylation

(2) Products from Gauhati refinery have an established market.

(3) A fibre plant from 24000 t DMT would need an additional investment of Rs. 15 crores,

CHAPTER VII

7.0 CONCLUSIONS

7.1 The known crude oil reserves in Assam are likely to sustain a production rate of about 4.1 million tonnes per year from 1971 onwards upto 1977 and a decreasing rate thereafter. However, the maximum possible rate of production on the basis of established reserves could be as follows :

1971	...	4.6263 million tonnes
1972	...	4.6167 " "
1973	...	4.6060 " "
1974	...	4.5955 " "
1975	...	4.5865 " "
1976	...	4.5780 " "
1977	...	4.5700 " "
1978	...	4.2630 " "
1979	...	4.0570 " "

7.2 The three refineries operating on crude oil produced in Assam have the following design capacities :—

Digboi	...	0.525 million tonnes/year
Gauhati	...	0.75 million tonnes/year
Barauni	...	3.00 million tonnes/year
Total :		4.275 million tonnes/year

With marginal additional investment the built in capacities of these refineries can be utilised to operate as follows :—

Digboi	...	0.525 mtpa
Gauhati	...	1.1 mtpa
Barauni	...	3.4 mtpa
Total :		5.025 mtpa

7.3 These refineries are designed specifically to process the low-sulphur crude oils from the Nahorkatiya-Moran fields. It is not possible to process imported high-sulphur crude oils in these refineries without extensive modifications, which may involve, in addition to the provision of new lining in the fractionating towers and transfer lines, the installation of secondary processing units like Reformer, Desulphurisation Unit and Visbreaker, at considerable capital cost. Since it is to the economic advantage of the country to operate these refineries at their optimum capacities, crude oil produced from the Assam oil-fields upto 5.025 million tonnes should be supplied to these refineries on a first priority basis, subject to the suitability of economic processing of the crude oil likely to become available from the new Assam fields as per para 7.10 below,

7.4 Since the rate of crude oil production from the Assam oil fields in the foreseeable future will be considerably less than the optimum capacities of the refineries at Digboi, Gauhati and Barauni, it is not considered necessary to create additional refining capacity of the conventional type for processing the crude oil presently estimated to be available in Assam.

7.5 The prospecting operations of ONGC and OIL may in the future establish the presence of additional reserves of crude oil. Based on this hypothesis, a techno-economic study of the feasibility of installing additional refining capacity at a suitable place has been made. For this purpose, the over-all comparative costs of transportation and refining in establishing additional refining capacity at alternative locations, namely, Galeki-Nazira, Gauhati, Dhubri, Barauni and Kanpur have been studied on the basis of

- (i) one million tonne per annum and
- (ii) two million tonnes per annum

of crude oil production being available over and above the 5 million tonnes per annum required for the existing refineries at their optimum capacities.

7.6 The total consumption of major petroleum products in Assam is estimated to be 1.09 million tonnes during 1975 and 1.66 million tonnes by 1980. The present refining capacity of 1.625 million tonnes in Assam will be enough to meet the local requirements of all major products except kerosene upto 1980. Since the additional requirements of kerosene can be met economically by movement from outside, it is seen that there is no need to increase the refining capacity in Assam to meet the local requirements of refined products.

7.7 A study of the pattern of demand for petroleum products and of the economics of transportation of products from alternative refineries to the various consuming centres has shown that the market for the products from any additional refining capacity will by and large be in the area west of Kanpur.

7.8 The cost of movement of crude oil and refined products (by pipeline for white products upto Delhi) calculated on the basis of actual pipeline costs and railway freight rates, and the refining costs for 1 mtpa and 2 mtpa additional refining capacity with coking operation are estimated as follows :—

	(Rs. Lakhs)				
	Galeki-Nazira	Gauhati	Dhubri	Barauni	Kanpur
1 mtpa					
Cost of transportation of crude oil	—	200	360	440	780
Cost of transportation of products	1255	934	878	680	253
Cost of refining	362	332	357	278	349
Total Cost	1617	1466	1595	1398	1382
2 mtpa					
Cost of transportation of crude oil	—	280	440	700	1080
Cost of transportation of products	1719	1448	1403	974	395
Cost of refining	608	560	596	473	586
Total Cost	2927	2288	2439	2147	2061

These calculations show that for a throughput of either one million or two million tonnes per year the total costs will be the lowest if additional refining capacity is located at Kanpur. However, the advantage to Kanpur would be modified if calculations could be based on costs of rail haul rather than railway freight rates. A refinery too far to the West would also impinge on the economics of supply of

crude by the producer of crude oil. If the choice is limited to the first four locations, Barauni is the most economical choice for an additional throughput of 2 mtpa and Barauni and Gauhati are more or less comparable if the additional refining capacity is only 1 mtpa, since the slight advantage to Barauni may be modified by the difference between railway freight rates and railway costs. Thus, if the additional finds of crude oil in Assam are of the order of one million tonne per annum and if resources can be found by the railways to cope with the additional requirements of rolling stock, etc., the feasibility of creating additional refining capacity of the conventional type for 1 million tonne throughput at Gauhati or Barauni could be considered, subject to the consideration that in the context of the substantial deficit of petroleum products appearing in the north-western region by 1973-1974, the creation of additional refining capacity there might also be necessary.

7.9 It is considered that the refining of crude oil for the production of conventional petroleum products is not the only optimum way of utilising crude oil. Processing of crude oil as a chemical feed-stock for the production of aromatics, ammonia and ethylene-based petrochemicals also presents attractive economic possibilities. In the context, in particular, of utilising additional crude oil from Assam oil-fields, these possibilities appear all the more attractive since

- (a) the market for petroleum products from additional crude oil finds will by and large be in far-off areas viz. western Uttar Pradesh and beyond resulting in expensive transportation ;
- (b) there will be considerable unsatisfied demand for ammonia in West Bengal, North Bihar and Uttar Pradesh in the years to come ;
- (c) Aromatics, especially after conversion to high-priced DMT, cyclohexane, synthetic fibres, etc. will command good market and bear long haulage costs ; and
- (d) Aromatics and ethylene-based chemicals can become the nucleus for the development of economic activity for the ultimate production of consumer products ; a conventional refinery by itself cannot generate such economic activity and increase employment potential.

7.10 The present knowledge about the characteristics of the initial production of crude oils from Lakwa and Rudrasagar is not adequate and it is not known whether these crude oils will be suitable for economic processing at Barauni, in particular for the production of certain high-priced products. No information is available about the quality of any new crude oil finds. The quality of these crude oils will not, however, affect their suitability as a feed-stock for the production of chemicals. An integrated complex for the production of chemicals and kerosene is worthy of serious consideration, when additional crude oil production of either one or two million tonnes is established. In the limited time available to the Committee it has not been possible to establish the economics of such a chemical complex. This matter needs to be studied further by a separate technical group.

7.11 As stated above, the present knowledge of the characteristics of the Lakwa and Rudrasagar crude oils is not adequate ; regarding the characteristics of the crude oil from any new finds there is presently no information whatsoever. If the characteristics of the aforesaid crude oils should warrant employing a more sophisticated technology compared to what has been envisaged in Chapter III, the cost of refining will increase. In such an event, the comparative economics of processing the aforesaid crude oils at Barauni and of using a suitable imported crude oil to supplement the Nahorkatiya and Moran crude oils for processing at Barauni (along with the economics of using the existing Haldia-Barauni pipeline for crude oil transportation and of the consequential movement of refined products from the refinery at Haldia by rail) will need to be examined. If the economics of the alternatives available justifies the importation of crude oil of the order of 1.4 mtpa for processing at Barauni, only about 2 mtpa will need to be supplied from Assam to Barauni. The total requirements of the three refineries for Assam crude oils will then be $2.0 + 1.1 + 0.525$ i.e. 3.625 mtpa. Thus in the above situation, even with the normal crude oil production

rate of 4.1 mtpa or the maximum possible production rate of 4.6 mtpa, there will be a surplus of 0.5 to 1.0 mtpa of crude oil in Assam for utilisation in the above-mentioned chemical complex.

(M. G. KRISHNA)
Member

(B. S. NEGI)
Convenor

(S. D. BHAMBRI)
Member

(A. K. GHOSH)
Member

(HARI NARAIN)
Member



New Delhi
11th September 1969

सत्यमेव जयते

GOVERNMENT RESOLUTION
(TO BE PUBLISHED IN THE GAZETTE OF INDIA, PART I, SECTION I)
GOVERNMENT OF INDIA
MINISTRY OF PETROLEUM & CHEMICALS AND MINES & METALS
(DEPARTMENT OF PETROLEUM)
NEW DELHI, 2ND APRIL, 1969

RESOLUTION

No. 25 (1)/68—OR—The Government of India are pleased to constitute an Experts' Committee consisting of the following persons to study and report upon the techno-economic feasibility of locating another oil refinery at a suitable location in Assam :

- (1) Shri B.S. Negi, Member (Exploration) ONGC (Convenor).
 - (2) Dr. Hari Narayan, Director, National Geophysical Research Institute.
 - (3) Dr. M. G. Krishna, Director, Indian Institute of Petroleum.
 - (4) Dr. A. K. Ghosh, Economic Adviser, Railway Board.
 - (5) Shri S. D. Bhambri, General Manager, IOC (Marketing Division).
2. The Experts' Committee will study and report on the following :—
- (i) Crude oil resources of Assam, yearly rate of production from the various fields and the quantities that will remain available after meeting fully the requirements of the existing refineries at Digboi, Gauhati and Barauni operating to their optimum design capacities.
 - (ii) The nature and extent of demand for petroleum products within the State of Assam existing and in future, and the area of economic distribution for marketing the additional production.
 - (iii) Techno-economic feasibility and comparative economics of establishing a new refinery or expansion of one or more of the existing plants, taking also into account the means of transport available or proposed.
 - (iv) Other relevant factors which may have a bearing on the establishment of the additional refining capacity in Assam.
3. The Committee should also consider the views of the Government of Assam and others on this subject. The Committee should submit its report to the Government of India within a period of three months.

Sd/—M. V. RAJWADE
JOINT SECRETARY TO THE GOVERNMENT OF INDIA

Copy for information to :

- (1) All Ministries/Departments of the Government of India, etc, etc.
- (2) The Govt. of Assam, Industries Deptt., Major Industries, Shillong.
- (3) All persons mentioned in paragraph 1 above.
- (4) Press Information Officer, Min. of P&C.

Sd/— (R. K. SINHA) 7.4.69
UNDER SECRETARY TO THE GOVERNMENT OF INDIA.

Particulars of letters addressed to various authorities requesting for information and replies thereto.

Sl. No.	Subject(s) on which information was requested	Information requested from		Particulars of Committee's letter		Reply to Committee's letter		Remarks
		No.	Date	No.	Date	No.	Date	
1	2	3	4	5	6	7	8	
1.	Details of crude oil reserves and crude oil production rates, field-wise, in Assam.	Chairman, oil and Natural Gas Commission.	9/9/69-M(E)	27.4.1969	PS/CH/52/69/172	12.5.1969		
2.	—Ditto—	Managing Director, Oil India Ltd.	—Ditto—	—Ditto—	OIL 1/1/1	21.5.1969		
3.	—Ditto—	General Manager, Assam Oil Co. Ltd.	—Ditto—	—Ditto—	TM. 162/IRP/69	12.5.1969		
4.	Crude oil throughput, optimum design capacity, production of various products, maximum throughput and plans for expansion, in respect of the Digboi Refinery.	General Manager, Assam Oil Co.	—Ditto—	—Ditto—	TM. 152/IRP/69	8.5.1969		
5.	—Ditto— in respect of Gauhati and Barauni refineries ; also, sales product-wise and projections of demand.	Chairman, Indian Oil Corporation.	—Ditto—	—Ditto—	(i) 114-9/13 (3298) (ii) 114-9/13 (3360)	6.6.1969 19.6.1969		
6.	Capacity of OIL's crude oil pipeline, additional capacity that can be feasible and cost of transportation of crude oil for additional quantities upto 4 mtd.	Managing Director, Oil India Ltd.	9/9/69-M(E)	27.4.1969	(i) OIL 1/1/1 (ii) OIL 1/1/1	3.6.1969 9.8.1969		
7.	Data pertaining to crude oil reserves and production rate forecasts, projection of demand for products, and other data relevant to the study ; results of studies	Secretary, Industries Deptt., Shillong.	9/9/69-M(E)	27.4.1969	(i) MI. 260/65/296 (ii) MI. 260/65/295 (iii) MI. 260/65/304	9.6.1969 7.6.1969 26.6.1969		

1	2	3	4	5	6	7	8
	made by Govt. of Assam ; views of Govt. of Assam.						
8.	Projections of demand for various petroleum products and results of studies on techno-economic feasibility of establishing additional refining capacity in Assam.	Director, Indian Institute of Petroleum.	9/9/69-M(E)	27.4.1969	(i) 25.16.081 (ii) 25.16.081/11708 (iii) IIP/DIR/69/6015	6.5.1969 19.5.1969 24.6.1969	
9.	Projections of demand for various petroleum products.	Shri M.V. Rajwade, Jt. Secretary to Govt. of India, Ministry of P&C and M & M.	9/9/69-M(E)	27.4.1969	4(3)/69-CRPD	15.5.1969	
10.	Examination of ONGC's estimates of crude oil reserves in its fields in Assam.	Shri M. B. Ramachandra Rao.	9/9/69-M(E)	27.4.1969	—	19.6.1969	
11.	—Ditto—	Dr. I.P. Sokolov.	—Ditto—	27.4.1969	—	19.6.1969	
12.	Optimum design capacities of Digboi, Gauhati and Barauni Refineries.	Shri M.V. Rajwade, Jt. Secretary to Govt. of India, Ministry of P&C and M&M.	9/9/69-M(E)	17.7.1969	—	22.7.1969	
13.	Possibility of manufacture of petrochemicals and aromatics from Assam crudes.	—	—	—	Secretary to Govt. of India, Ministry of P & C & M&M D.O. No. 25(1)/68-OR	19.7.1969	
14.	Cost of transportation of various products from additional refining capacity of 1 mta/2 mta at various alternative locations to their respective consumption centres; also cost of transportation of crude oil to various alternative locations of additional refining capacity.	Shri N.N. Kashyap Chairman, Indian Oil Corporation.	9/9/69-M(E)	4.8.1969	(i) 114-9/13 (ii) Shri D.C. Roy, Staff Engineer, D.O. letter No. Nil.	21.8.1969 8.9.1969	

1	2	3	4	5	6	7	8
15.	Cost of transportation of crude to various alternative refinery locations.	Shri L. J. Johnson, Chairman, Oil and Natural Gas Commission.	9/9/69-M(E)	4.8.1969	HOD/AM/661.2	3.9.1969	
16.	Refining costs at various alternative locations for additional refining capacity.	—	—	—	Furnished by Shri S.C. Gupta on behalf of Director, I.I.P.	17.7.1969	
17.	Comments of ONGC Specialist on report of Shri M.B. Ramachandra Rao and Dr. I. P. Sokolov.	—	—	—	—	12.8.1969	Comments had been requested for by Conve-ner.



ANNEXE III

(D. O. letter No. 9/9/69-M(E), dated 17-7-1969, from Shri B. S. Negi to Shri M. V. Rajwade).

Subject :—Study of the Techno-Economic feasibility of locating another oil refinery in Assam.

Kindly refer to the Government of India, Ministry of Petroleum and Chemicals and Mines & Metals (Deptt. of Petroleum), Resolution dated 2-4-1969, constituting an Experts Committee to study and report upon the techno-economic feasibility of locating another oil refinery at a suitable location in Assam.

As per the above-mentioned Resolution, the Experts Committee is to study and report on, inter alia, the quantities of the crude oil that will remain available after meeting fully the requirements of the existing refineries at Digboi, Gauhati and Barauni operating to their optimum design capacities. Enquiry was made from the Assam Oil Company and the I. O. C., regarding optimum design capacities of the Digboi refinery and the Gauhati and Barauni refineries, respectively. The Assam Oil Company has informed the Experts Committee that the optimum refining capacity that can presently be sustained by the Digboi refinery is approximately 0.525 million metric tons, per year. Likewise, the I. O. C. has informed us that the optimum design capacities of the Gauhati refinery and the Barauni refinery are 0.75 million tons, per year, and 3.0 million tons, per year, respectively. I shall be grateful if you will kindly indicate whether the Experts Committee should use the afore-said figures for the optimum design capacities of these refineries, for the purpose of the study envisaged in the above mentioned Government Resolution.

We are seeking clarification in this regard, as it appears that the Government have separately decided that throughputs of the Digboi, Gauhati and Barauni refineries would be 0.5 million tons, per year, 1.1 million ton, per year, and 3.4 million tons, per year, respectively. Furthermore, we have been informed by the I. O. C. that the maximum throughputs that can be achieved with minor modifications and de-bottlenecking are 0.8 million tons per year, in case of the Gauhati Refinery and 3.4 million tons, per year, in the case of the Barauni Refinery. We have further been informed by the I. O. C. that the Barauni Refinery is capable of still higher throughput, i. e. 4 million tons, per year, after certain revamping and de-bottlenecking.

I shall be grateful if you will kindly indicate which figures should be used by the Experts Committee for the optimum design capacities of the above mentioned three refineries for the purpose of their study.

With kind regards,

Yours sincerely,
Sd/-(B. S. Negi) 17-7-69.

Shri M. V. Rajwade,
Jt. Secretary,
Ministry of Petroleum & Chemicals and Mines and Metals, Shastri Bhavan, New Delhi.

Copy forwarded for information to :—

1. Dr. M. G. Krishna, Director, Indian Instt : of Petroleum, MOKHAMPUR, Dehradun.
2. Dr. Hari Narain, Director, N. G. R. I. Hyderabad.
3. Dr. A. K. Ghosh, Economic Adviser, Ministry of Industry Development, Internal Trade & Co. Affairs, Udyog Bhavan, New Delhi.
4. Shri S. D. Bhambri, General Manager (Marketing Divn), Indian Oil Corpn., Dr. Annie Besant Road, Prabhadevi, Bombay—25 DD.

Sd/-(B. S. Negi) 17-7-1969.

ANNEXE IV

(D. O. letter No. Nil, dated 22-7-1969, from Shri M. V. Rajwade, Joint Secretary to Govt. of India, Ministry of P & C & M & M to Shri B. S. Negi).

My dear Negi,

Please refer to your letter No. 9/9/69-M(E) dated 17th July, 1969, regarding study of the techno-economic feasibility of locating another oil refinery in Assam. I confirm that the design capacities of the Gauhati and Barauni refineries are 0.75 tonnes per year and 3.00 tonnes per year respectively. In so far as the Digboi refinery is concerned, you may consult the Second Supplemental Agreement between the Government of India and the BOC, detailing the liability of the Oil India to supply certain stipulated quantities of crude to Digboi from the Oil India fields. It is true that we are estimating the actual throughput of the Barauni Refinery at 3.4 million tonnes. This is on the presumption that a design capacity of 3 million tonnes will have approximately 10% margin built in its design capacity. As at present, there is no intention of boosting Barauni Refinery's capacity to a higher throughput of 4 million tonnes by revamping and de-bottlenecking. If the crude situation improves, the question will be examined.

2. Although the design capacity of Gauhati refinery is 0.75 million tonnes, it has operated at 0.80 million tonnes in the past, but Govt. has recently taken a decision to upgrade the capacity of this refinery to 1.1 million tonnes per year. How soon this can be brought into commission is a matter now under examination.

With kind regards,



Yours sincerely,
Sd/-
(Madhav Rajwade)

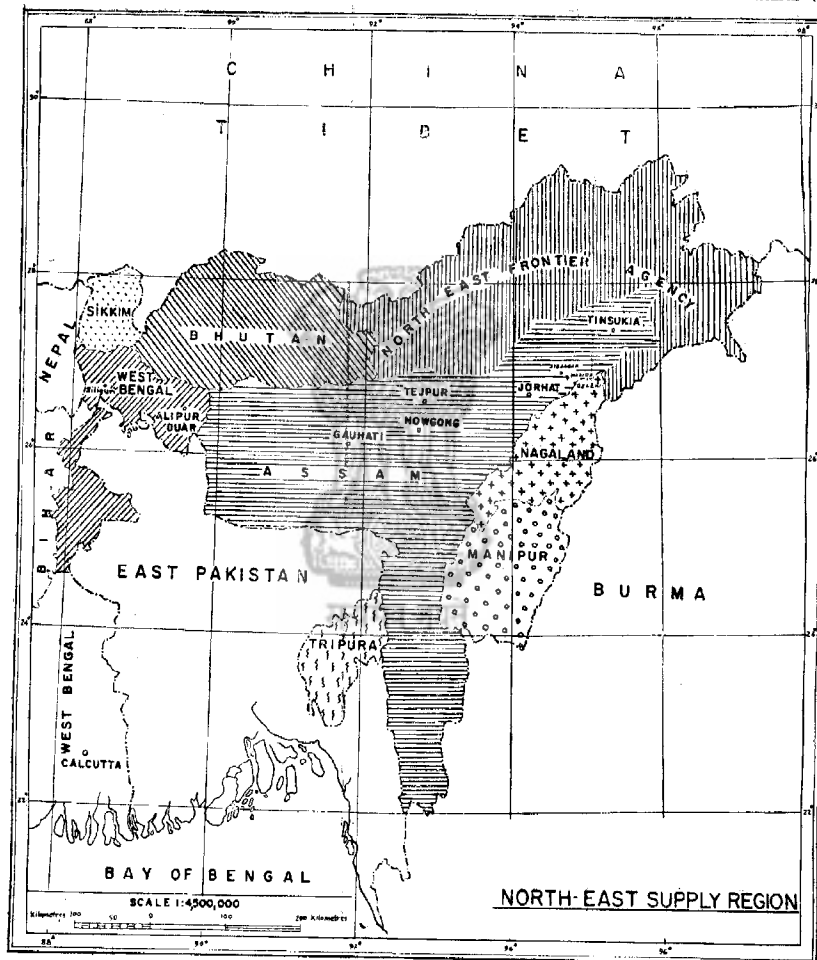
Shri B. S. Negi,
Member (Exploration),
Oil & Natural Gas Commission,
Tel Bhavan, Dehra Dun.

ANNEXE V

PRODUCTION PATTERN OF EASTERN REFINERIES AND FOR PROCESSING SCHEMES IN RESPECT OF ADDITIONAL
REFINING CAPACITY EXAMINED IN CHAPTER III

REFINERY	'000 tonnes												
	DIGBOI	GAUHATI		NEW REFINERY (Assam)				TOTAL FOR ASSAM				BARAUNI	HALDIA
	0.5	1.1		1.0		2.0		2.6		3.6		3.4	3.5
Capacity in million tonnes				Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb		
M/S NAPHTHA	90	181		84	120	168	240	355	391	439	511	560	562
KERO/ATF	90	130		122	122	244	244	342	464	464	464	349	532
HSD	55	309		240	265	480	530	604	629	844	894	894	662
LDO	40	94		—	101	—	202	134	235	134	336	200	—
FO/TDO	80	80		—	60	—	120	160	220	160	280	155	950
LSHS)From new refinery				501	201	1002	402						
COKE)				—	36	—	72						

ANNEXE VI



Based upon Survey of India map with the permission of the Surveyor General of India. The External Boundary of India on the map agrees with the Record copy certified by the Survey of India.

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ANNEXE VII

CONSUMPTION OF MAJOR PETROLEUM PRODUCTS IN THE NORTH-EAST REGION IN 1968

Figures '000 MTs

	MS	KERO	ATF/JP-4	HSD	LDO	FO (Reg)	BITUMEN	TOTAL
Silliguri	9.1	21.4	1.8	26.5	7.6	1.0	4.8	72.2
Allipurdwar	9.5	24.9	6.0	16.7	11.1	18.1	2.1	88.4
(a) SUB-TOTAL	18.6	46.3	7.8	43.2	18.7	19.1	6.9	160.6
Gauhati	20.9	44.4	2.9	28.7	3.1	4.2	6.2	110.4
Tejpur	9.3	14.3	5.7	9.3	4.1	16.6	1.9	61.2
Nowgaon	5.5	12.2	—	8.5	3.1	2.3	0.4	32.0
Badarpur	5.4	11.5	—	7.5	2.8	4.3	2.2	33.7
Jorhat	15.4	19.6	4.3	19.6	5.1	20.0	1.1	85.1
Tinsukhia	15.3	22.4	0.8	16.1	7.8	37.8	5.0	105.2
(b) SUB-TOTAL	71.8	124.4	13.7	89.7	26.0	85.2	16.8	427.6
Manipur	6.3	4.7	—	3.8	0.2	—	0.8	15.8
Tripura	5.1	9.5	1.0	4.3	2.1	0.2	2.0	24.2
Sikkim	1.6	1.2	—	1.5	0.1	—	0.4	4.8
Bhutan	1.2	0.4	—	1.0	—	—	4.0	6.6
(c) SUB-TOTAL	14.2	15.8	1.0	10.6	2.4	0.2	7.2	51.4
GRAND TOTAL								
(a) + (b) + (c)	104.6	186.5	22.5	143.5	47.1	104.5	30.9	639.6
= North East								

ANNEXE VIII

DEMAND FOR MAJOR PETROLEUM PRODUCTS IN THE NORTH-EAST REGION—PROJECTIONS UPTO 1980

(Figures in 000 MTs)

Year	MS	KERO	ATF/JP-4	HSD	LDO	FO (Reg.)	BITUMEN	TOTAL
1969	105.5	206.7	25.0	162.1	48.3	107.4	33.4	688.4
1970	106.2	227.0	28.0	183.0	49.5	110.9	36.0	740.6
1971	107.0	249.2	31.0	206.6	50.7	114.0	38.9	797.4
1972	107.0	271.0	35.0	233.1	51.9	119.4	42.0	860.1
1973	108.3	294.5	39.0	262.8	53.1	125.1	45.4	928.2
1974	108.8	320.0	44.0	296.3	54.3	130.8	49.0	1003.2
1975	109.3	347.6	49.0	333.8	55.4	137.2	52.9	1085.2
1980	114.9	534.8	82.5	615.0	61.2	175.1	77.7	1661.2

ANNEXE IX

ESTIMATED GROWTH RATE OF CONSUMPTION OF MAJOR PETROLEUM PRODUCTS IN NORTH EAST REGION

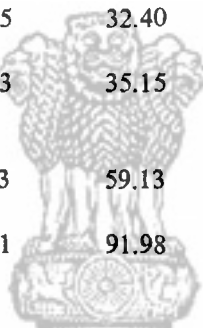
% INCREASE/(DECREASE)

	MS	KERO	ATF/JP-4	HSD	LDO	FO (Reg)	BITUMEN	TOTAL
1963 to 1968								
Annual Compound Growth Rate	(1.1)	8.5	16.0	12.7	1.8	3.3	(3.3)	5.4
1969	1.0	11.0	11.0	13.0	3.0	3.0	8.0	7.9 Annual Compound Growth Rate
1970	1.0	10.0	12.0	13.0	3.0	3.0	8.0	
1971	1.0	10.0	11.0	13.0	2.0	3.0	8.0	
1972	1.0	9.0	13.0	13.0	2.0	5.0	8.0	
1973	1.0	9.0	11.0	13.0	2.0	5.0	8.0	
1974	1.0	9.0	13.0	13.0	2.0	5.0	8.0	7.9 Annual Compound Growth Rate
1975	1.0	9.0	11.0	13.0	2.0	5.0	8.0	
1976 to 1980								
Annual Compound Growth Rate	1.0	9.0	11.0	13.0	2.0	5.0	8.0	8.9

COMPARATIVE STATEMENT SHOWING COST FOR TRANSPORTATION

A. THROUGHPUT

Sl. No.	Refinery Locations	By constructing a new pipeline			Using OIL Pipeline upto Borauni			
		Pipe dia. (Inches)	Capital cost (crores of Rs.)	Transportation Cost/tonne (Rs.)	Pipe dia (Inches)	Capital Cost (Crores of Rs.)		Transportation Cost/tonne (Rs.)
						Total	additional, for throughput over and above 3.75/3.00 M.T.A.	
1	2	3	4	5	6	7	8	9
1.	Gauhati	12	17.33	22.52	16	25.48	11.57	13.20
2.	Gossaigaon	12	25.15	32.40	16/14	37.92	17.98	18.00
3.	Dhubri	10	26.33	35.15	--	—	—	21.00 (Approx)
4.	Barauni	12	46.03	59.13	16/14	65.44	28.10	28.55
5.	Kanpur	12	71.51	91.98	16/14/10	90.54	53.20	63.18



सत्यमेव जयते

B. THROUGHPUT--2 M. T. A.

1.	Gauhati	16	23.39	14.45	16	29.08	15.17	10.79
2.	Gossaigaon	12	31.86	20.66	16/14	45.00	25.06	15.78
3.	Dhubri	12	33.19	21.54	—	—	—	—
4.	Barauni	14	56.48	35.29	16/14	83.99	46.65	27.94
5.	Kanpur	12	83.98	54.27	16/14, 12	113.69	76.35	47.66

OF CRUDE TO VARIOUS ALTERNATIVE REFINERY LOCATIONS

ANNEXE X-A

1 M. T. A. (over and above 3.75/3.00 M. T. A.)

<i>a new pipeline beyond</i>		<i>Using OIL pipeline upto Gauhati and a new pipeline beyond.</i>					
<i>Extra differential cost/tonne (Rs.)</i>	<i>Total Tptn./cost/tonnes (Rs.)</i>	<i>Pipe dia. (inches)</i>	<i>Capital Cost (Crores of Rs.)</i>		<i>Transportation Cost/tonne (Rs.)</i>	<i>Extra differential cost/tonne (Rs.)</i>	<i>Total transportation cost/tonne (Rs.)</i>
			<i>Total</i>	<i>Additional, from throughput over and above 3.75/3.00 M.T.</i>			
10	11	12	13	14	15	16	17
6.50	19.70	16	25.48	11.57	13.20	6.50	19.70
15.00	33.02	16/10	33.61	19.70	24.39	—	24.39
15.00	36.00 (Approx)	—	—	—	27.39 (Approx)	—	27.39 (Approx)
15.15	43.70	16/10	53.52	39.61	51.88	—	51.88
15.15	78.33	16/10	78.62	64.71	86.51	—	86.51
(over and above 3.75/3.00 M.T.A.).							
—	10.79	16	29.08	15.17	10.79	—	10.79
4.13	19.91	16/14	39.12	25.21	17.24	—	17.24
—	—	—	—	—	20.24 (Approx)	—	20.24 (Approx)
6.66	34.60	16/14	63.89	49.98	33.10	—	33.10
6.66	54.32	16/12	91.68	77.77	52.36	—	52.36

ANNEXE X-B

INVESTMENT ON NEW WHITE OIL PRODUCT PIPELINES AND UNIT
COSTS OF TRANSPORTATION

<i>Pipeline</i>	<i>Cases</i>	<i>Line (inches dia.) Size</i>	<i>Pipeline & Ancil- lary facilities (Rs. Crores)</i>	<i>Unit cost of trans- portation Rs./tonne</i>
Galeki-Siliguri (836 Kms.)	Ia	8	16.13	76
	Ib	8	16.5	51
	IIa	10	17.85	38
	IIb	10	18.5	25
Galeki-Barauni (1100 Kms.)	Ia	8	21.53	100
	Ib	8	22.00	67
	IIa	10	24.00	51
	IIb	10	24.4	34
Galeki-Kanpur (1800 Kms.)	Ia	8	34.7	160
	Ib	8	35.5	107
	IIa	10	39.0	83
	IIb	10	39.60	52
Galeki-Delhi (2250 Kms.)	Ia	8	43.5	201
	Ib	8	44.5	134
	IIa	10	48.8	92
	IIb	10	50.0	61
Gauhati-Siliguri (426 Kms.)	Ia	8	8.0	39
	Ib	8	8.5	26
	IIa	10	9.6	19
	IIb	10	9.75	12
Gauhati-Barauni (690 Kms.)	Ia	8	13.70	63
	Ib	8	14.0	42
	IIa	10	15.25	32
	IIb	10	15.5	21
Gauhati-Kanpur (1390 Kms.)	Ia	8	26.8	125
	Ib	8	27.5	83
	IIa	10	30.0	63
	IIb	10	30.5	42
Gauhati-Delhi (1840 Kms.)	Ia	8	35.4	164
	Ib	8	36.5	110
	IIa	10	37.7	78
	IIb	10	38.6	52
Dhubri-Siliguri (310 Kms.)	Ia	8	6.25	28
	Ib	8	6.35	19
	IIa	10	7.07	14
	IIb	10	7.20	9

<i>Pipeline</i>	<i>Cases</i>	<i>Line (inches dia.) Size</i>	<i>Pipeline & Ancil- lary facilities (Rs. crores)</i>	<i>Unit cost of trans- portation Rs./tonne</i>
Dhubri-Barauni (574 Kms.)	Ia	8	11.25	52
	Ib	8	11.5	35
	IIa	10	12.8	26
	IIb	10	13.0	17
Dhubri-Kanpur (1274 Kms.)	Ia	8	24.63	115
	Ib	8	25.20	77
	IIa	10	27.85	58
	IIb	10	28.25	39
Dhubri-Delhi (1724 Kms.)	Ia	8	30.48	152
	Ib	8	31.20	101
	IIa	10	34.30	76
	IIb	10	35.00	51
Barauni-Kanpur (700 Kms.)	Ia	8	13.69	64
	Ib	8	14.0	43
	IIa	10	15.54	32
	IIb	10	15.80	21
Barauni-Delhi (1150 Kms.)	Ia	8	24.5	105
	Ib	8	25.0	71
	IIa	10	27.60	53
	IIb	10	28.0	36
Kanpur-Delhi (450 Kms.)	Ia	8	8.60	41
	Ib	8	8.82	27
	IIa	10	10.34	21
	IIb	10	10.6	13

**PATTERN OF
DISTRIBUTION EX-EASTERN REFINERIES-1975**
Product : MS

('000 tonnes)

Consumption points	Ex. New Refinery				Ex. AOC	Ex. GHT	Ex. BNI	Ex. HLD
	Case Ia	Case Ib	Case IIa	Case IIb				
Production	84.0	120.0	168.0	240.0	90.0	181.0	125.0	268.0
Distribution								
N.E. AREA								
Navagaon	—	—	—	—	5.8	—	—	—
Badarpur	—	—	—	—	5.6	—	—	—
Jorhat	—	—	—	—	16.1	—	—	—
Tinsukia	—	—	—	—	16.0	—	—	—
Manipur	—	—	—	—	6.6	—	—	—
Tripura	—	—	—	—	5.3	—	—	—
Gauhati	—	—	—	—	—	21.8	—	—
Tezpur	—	—	—	—	9.7	—	—	—
Alipurduar	—	—	—	—	9.9	—	—	—
Bhutan	—	—	—	—	1.3	—	—	—
Siliguri	—	—	—	—	9.5	—	—	—
Sikkim	—	—	—	—	1.7	—	—	—
Sub-Total	—	—	—	—	87.5	21.8	—	—
BNI AREA								
Katihar	—	—	—	—	2.5	2.3	—	—
Muzaffarpur	—	—	—	—	—	11.6	—	—
Nepal	—	—	—	—	—	12.3	—	—
Gorakhpur	—	—	—	—	—	12.1	—	—
Bhagalpur	—	—	—	—	—	—	—	13.7
Patna	—	—	—	—	—	—	16.2	—
Gaya	—	—	—	—	—	—	20.2	—
Varanasi	—	—	—	—	—	—	16.2	—
Allahabad	—	—	—	—	—	—	12.3	—
Satna	—	—	—	—	—	—	3.0	—
Kanpur	—	—	—	—	—	—	15.2	—
Lucknow	—	—	—	—	—	—	13.9	—
Sitapur	—	—	—	—	—	—	1.8	—
Shahajahanpur	—	—	—	—	—	—	0.7	—
Sub-Total	—	—	—	—	2.5	38.3	99.5	13.7
HLD AREA								
Asansol	—	—	—	—	—	—	—	18.1
Dhanbad	—	—	—	—	—	—	—	9.7
Rampurhat	—	—	—	—	—	—	—	3.5
Tatanagar	—	—	—	—	—	—	—	11.7
Ranchi	—	—	—	—	—	—	—	7.3
Rourkela	—	—	—	—	—	—	—	3.5
Kharagpur	—	—	—	—	—	—	—	4.7

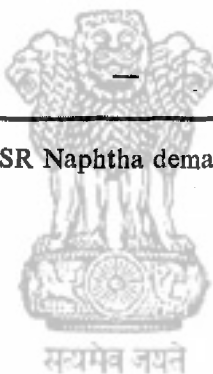
('000 tonnes)

Consumption points	Ex. New Refinery				Ex. AOC	Ex. GHT	Ex. BNI	Ex. HLD
	Case Ia	Case Ib	Case IIa	Case IIb				
Balasore	—	—	—	—	—	—	—	4.5
Calcutta	—	—	—	—	—	—	—	127.1
Andaman	—	—	—	—	—	—	—	0.5
<i>Sub-Total</i>	—	—	—	—	—	—	—	190.6
N.W. AREA								
Aligarh	—	—	—	—	—	—	3.2	—
Bareilly	—	—	—	—	—	—	6.4	—
Moradabad	—	—	—	—	—	6.3	3.2	—
Meerut	—	—	—	—	—	11.0	—	—
Saharanpur	—	—	—	—	—	12.3	—	—
Ambala	—	—	—	—	—	16.7	—	—
Chandigarh	—	—	—	—	—	6.2	—	—
Simla	—	—	—	—	—	3.6	—	—
Patiala	—	—	—	—	—	7.1	—	—
Ludhiana	—	—	—	—	—	10.2	—	—
Jullundur	—	—	—	—	—	22.3	—	—
Mandi	—	—	—	—	—	3.4	—	—
Pathankot	—	—	—	—	—	21.8	—	10.0
J&K	—	—	—	—	—	—	—	14.1
Ferozepur	—	—	—	—	—	—	—	11.2
Delhi	84.0	107.6	107.6	107.6	—	—	—	28.4
<i>Sub-Total</i>	84.0	107.6	107.6	107.6	—	120.9	12.8	63.7
KOYALI AREA								
Agra	—	—	—	—	—	—	10.8	—
Farukhabad	—	—	—	—	—	—	1.9	—
<i>Sub-Total</i>	—	—	—	—	—	—	12.7	—
KDL MG AREA								
Hissar	—	12.4	14.6	14.6	—	—	—	—
Jaipur	—	—	—	—	—	—	—	—
Jodhpur	—	—	—	—	—	—	—	—
<i>Sub-Total</i>	—	12.4	14.6	14.6	—	—	—	—
Grand Total Distribution	84.0	120.0	122.2	122.2	90.0	181.0	125.0	268.0
@ MS production ex New Refinery taken to the maximum possible extent of absorption.								
Balance Production	—	—	45.8	117.8	—	—	—	—
Total Production	84.0	120.0	168.0	240.0	—	—	—	—

PRODUCT : NAPHTHA

		('000 tonnes)			
	<i>Ex Barauni</i>	<i>Ex New Refinery</i>			
		<i>Ia</i>	<i>Ib</i>	<i>IIa</i>	<i>IIb</i>
Production	457	—	—	45.8	117.8
Distribution					
Gorakhpur Fertilizer	80				
Sindri Fertilizer	20				
Kanpur-Fuel Naphtha	70				
Barauni Fertilizer	160				
Barauni Aromatics	127				
Mirzapur		—	—	45.8*	117.8*

*The new refinery at Kanpur will meet SR Naphtha demand of 180,000 tonnes of Kanpur Fertilizer.



PRODUCT : KEROSENE/ATF

('000 tonnes)

Consumption Points	Ex New Refinery at BNI/Kanpur				Ex AOC	Ex GHT	Ex Barauni				Ex. Haldia			
	C. Ia	C. Ib	C. IIa	C. IIb			C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. IIb
Production	122.0	122.0	244.0	244.0	90.0	120.0	349.0	349.0	349.0	349.0	532.0	532.0	532.0	532.0
Distribution														
N. E. Area					0.7	22.0								
Navagaon						21.4								
Badarpur					45.5									
Jorhat					43.8									
Tinsukia						8.8								
Manipur						19.7								
Tripura						48.1	0.3	0.3	0.3	0.3	40.4	39.7	40.4	39.7
Gauhati							59.4	59.4	59.4	59.4	39.7	39.7	40.4	40.4
Tezpur							0.8	0.8	0.8	0.8	39.7	39.7	39.7	39.7
Alipurduar							43.9	43.9	43.9	43.9	39.7	39.7	40.4	40.4
Bhutan							2.2	2.2	2.2	2.2	39.7	39.7	40.4	40.4
Siliguri							2.2	2.2	2.2	2.2	39.7	39.7	40.4	40.4
Sikkim							2.2	2.2	2.2	2.2	39.7	39.7	40.4	40.4
Sub-Total					90.0	120.0	106.6	106.6	106.6	106.6	80.1	80.1	80.1	80.1
BNI AREA														
Katihar							25.3	25.3	25.3	25.3				
Muzaffarpur							43.1	43.1	43.1	43.1				
Nepal							23.3	23.3	23.3	23.3				
Gorakhpur							31.2	31.2	31.2	31.2				
Bhagalpur							57.3	57.3	57.3	57.3				
Patna							36.1	36.1	36.1	36.1				
Gaya														
Varanasi							52.2	52.2	52.2	52.2				
Allahabad							39.9	39.9	39.9	39.9				
Satna							9.1	9.1	9.1	9.1				
Kanpur							27.1	27.1	27.1	27.1				
Lucknow							21.0	21.0	21.0	21.0				
Sitapur							10.9	10.9	10.9	10.9				
Shahajahanpur							3.2	3.2	3.2	3.2				
Sub-Total					122.0	122.0	199.0	199.0	199.0	199.0	242.4	242.4	242.4	242.4

Consumption Points	Ex New Refinery at BNI/Kanpur				Ex AOC	Ex GHT	Ex Barauni				Ex Haldia			
	C. Ia	C. Ib	C. IIa	C. IIb			C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. IIb
HLD AREA														
Asansol														
Dhanbad														
Rampurhat														
Tatanagar														
Ranchi														
Rourkela														
Kharagpur														
Balasore														
Calcutta														
Andaman														
Sub-Total														
N. W. AREA														
Aligarh			17.0	17.0										
Bareilly			28.0	28.0										
Sub-Total			45.0	45.0										
Grand Total Distribution	122.0	122.0	244.0	244.0	90.0	120.0	349.0	349.0	349.0	349.0	532.0	532.0	532.0	532.0

PRODUCT : KEROSENE/ATF

('000 tonnes)

Consumption Points	Ex New Refinery at Nazira/GHT/Dhubri				Ex				Ex Barauni				Ex Haldia			
	C. Ia	C. Ib	C. IIa	C. IIb	AOC	GHT	C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. Ib	C. IIa	C. IIb
Production	122.0	122.0	244.0	244.0	90.0	120.0	349.0	349.0	349.0	349.0	532.0	532.0	532.0	532.0	532.0	532.0
Distribution																
N. E. Area																
Novgaon	...	...	...	...	0.7	22.0	...	...	...	...	...	...	...	...	...	...
Badarpur	...	...	...	...	...	21.4	...	...	...	...	...	...	...	...	...	...
Jorhat	...	...	...	...	45.5	...	...	...	...	...	...	...	...	...	...	...
Tinsukia	...	...	...	...	43.8	...	...	...	...	...	...	...	...	...	...	...
Manipur	...	...	...	...	...	8.8	...	...	...	...	...	...	...	...	...	...
Tripura	...	...	...	...	...	19.7	...	...	...	...	...	...	...	...	...	...
Gauhati	40.7	40.7	40.7	40.7	...	48.1	...	...	...	...	...	...	...	...	...	...
Tezpur	39.7	39.7	39.7	39.7	...	...	...	...	...	...	...	...	...	...	...	...
Alipurduar	41.6	41.6	59.4	59.4	...	...	...	...	...	...	17.8	17.8	...	...	...	...
Bhutan	...	...	0.8	0.8	...	...	0.8	0.8	...	...	...	...	...	...	...	...
Siliguri	...	...	43.9	43.9	...	...	43.9	43.9	...	...	...	...	...	...	...	...
Sikkim	...	...	2.2	2.2	...	...	2.2	2.2	...	...	...	...	...	...	...	...
Sub-Total	122.0	122.0	186.7	186.7	90.0	120.0	46.9	46.9	...	...	17.8	17.8	...	...	...	...
BNI AREA																
Kathar	...	...	...	...	25.3	25.3	25.3	25.3	25.3	25.3	...	...	...	...	...	...
Muzaffarpur	...	...	...	...	43.1	43.1	43.1	43.1	43.1	43.1	...	...	...	...	...	...
Nepal	...	...	...	...	23.3	23.3	23.3	23.3	23.3	23.3	...	...	...	...	...	...
Gorakhpur	...	...	...	...	66.8	66.8	66.8	66.8	66.8	66.8	...	...	...	...	...	...
Bhagalpur	...	...	...	...	57.3	57.3	57.3	57.3	57.3	57.3	...	...	...	...	...	...
Patna	...	...	...	...	36.1	36.1	36.1	36.1	36.1	36.1	...	...	...	...	...	...
Gaya	...	...	...	...	26.1	26.1	26.1	26.1	26.1	26.1	...	...	...	...	...	...
Varanasi	...	...	...	...	24.1	24.1	24.1	24.1	24.1	24.1	...	...	...	...	...	...
Allahabad	...	...	...	...	...	...	...	...	...	...	28.1	28.1	21.1	21.1	21.1	21.1
Satna	...	...	...	...	...	...	...	...	...	...	34.2	34.2	9.1	9.1	9.1	9.1
Kanpur	...	...	...	...	...	...	...	...	...	...	...	...	27.1	27.1	27.1	27.1
Lucknow	...	...	...	...	...	...	...	...	...	...	...	...	21.0	21.0	21.0	21.0
Sitapur	...	...	9.1	9.1	...	...	...	...	...	...	...	...	1.8	1.8	1.8	1.8
Shahjahanpur	...	...	3.2	3.2	...	...	...	...	...	...	...	...	...	...	...	...
Sub-Total	...	...	12.3	12.3	...	302.1	302.1	302.1	349.0	349.0	62.3	62.3	80.1	80.1	80.1	80.1

('000 tonnes)

Consumption Ex New Refinery at Nazira/GHT/Dhubri Ex Ex																				
Points	C. Ia			C. Ib			C. IIa			C. IIb			AOC		GHT		Ex			
	C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. IIb	C. Ia	C. Ib	C. IIa	C. IIb
HLD AREA																				
Asansol																	48.3	48.3	48.3	48.3
Dhanbad																	12.0	12.0	12.0	12.0
Rampurhat																	22.9	22.9	22.9	22.9
Tatanagar																	10.9	10.9	10.9	10.9
Ranchi																	16.2	16.2	16.2	16.2
Rourkela																	3.5	3.5	3.5	3.5
Kharagpur																	47.1	47.1	47.1	47.1
Balasore																	18.0	18.0	18.0	18.0
Calcutta																	273.0	273.0	273.0	273.0
Andaman																				
Sub-Total																	451.9	451.9	451.9	451.9
N. W. AREA																				
Aligarh																	17.0	17.0		
Bareilly																	28.0	28.0		
Sub-Total																	45.0	45.0		
Grand Total Distribution	122.0	122.0	244.0	244.0	90.0	120.0	349.0	349.0	349.0	349.0	532.0	532.0	532.0	532.0	532.0	532.0				

[illegible]

('000 tonnes)

Consumption points	Ex. New Refinery				Ex.AOC	Ex.GHT	Ex.BNI	Ex.HLD
	C.Ia	C.Ib	C.IIa	C.IIb				
Kharagpur	...	...	...	...	...	...	...	46.3
Balasore	...	...	...	...	...	...	...	20.1
Calcutta	...	...	...	...	...	...	...	204.2
Andaman	...	...	...	...	...	...	...	5.2
Sub-Total	...	...	...	...	...	...	...	543.0
N.W. AREA	...	...	...	...				
Aligarh	...	...	...	...	...	...	26.3	...
Bareilly	...	...	...	...	...	...	36.0	...
Moradabad	...	...	...	...	...	...	97.7	...
Meerut	...	...	...	...	...	...	35.5	25.4
Saharanpur	17.6	17.6	17.6	17.6	...	...	...	36.4
Ambala	84.4	84.4	84.4	84.4	...	...	...	...
Chandigarh	12.3	12.3	12.3	12.3	...	...	...	...
Simla	16.7	16.7	16.7	16.7	...	...	...	...
Patiala	57.3	57.3	57.3	57.3	...	...	...	...
Ludhiana	51.7	72.4	72.4	72.4	...	...	...	...
Jullundur	...	4.3	135.0	135.0	...	...	...	...
Mandi	...	...	26.3	26.3	...	...	...	...
Pathankot	...	...	58.0	100.3	...	...	...	...
J&K	...	...	...	7.7	...	...	...	...
Ferozepur	...	...	...	...	...	...	...	...
Delhi	...	...	...	...	...	...	...	...
Sub-Total	240.0	265.0	480.0	530.0	...	...	195.5	61.8
Koyali Area								
Agra	...	...	...	...	...	...	78.2	...
Farukhabad	...	...	...	...	...	...	18.2	...
Sub-Total	...	...	...	...	...	...	96.4	...
GRAND TOTAL DISTRIBUTION	240.0	265.0	480.0	530.0	55.0	309.0	894.0	662.0

PRODUCT : LDO

('000 tonnes)

Consumption points	Ex. New Refinery				Ex. AOC	Ex. GHT	Ex. BNI	Ex. HLD
	C.Ia	C.Ib	C.IIa	C.IIb				
Production	—	101.0	—	202.0	40.0	94.0	200.0	—
Distribution								
N.E. AREA								
Navagaon	—	—	—	—	3.6	—	—	—
Badarpur	—	—	—	—	3.3	—	—	—
Jorhat	—	—	—	—	6.0	—	—	—
Tinsukia	—	—	—	—	9.2	—	—	—
Manipur	—	—	—	—	0.2	—	—	—
Tripura	—	—	—	—	2.5	—	—	—
Gauhati	—	—	—	—	—	3.7	—	—
Tezpur	—	—	—	—	4.8	—	—	—
Alipurduar	—	—	—	—	10.4	2.7	—	—
Bhutan	—	—	—	—	—	—	—	—
Siliguri	—	—	—	—	—	8.9	—	—
Sikkim	—	—	—	—	—	0.1	—	—
Sub-Total	—	—	—	—	40.0	15.4	—	—
BNI AREA								
Katihar	—	—	—	—	—	9.6	—	—
Muzaffarpur	—	—	—	—	—	11.1	—	—
Nepal	—	—	—	—	—	7.2	—	—
Gorakhpur	—	—	—	—	—	12.8	—	—
Bhagalpur	—	—	—	—	—	—	12.5	—
Patna	—	—	—	—	—	—	1.9	—
Gaya	—	—	—	—	—	—	1.9	—
Varanasi	—	—	—	—	—	—	12.4	—
Allahabad	—	—	—	—	—	—	14.4	—
Satna	—	0.7	—	0.7	—	—	—	—
Kanpur	—	—	—	—	—	—	13.1	—
Lucknow	—	—	—	—	—	—	7.0	—
Sitapur	—	—	—	—	—	—	5.3	—
Shahajahanpur	—	—	—	—	—	—	1.2	—
Sub-Total	—	0.7	—	0.7	—	40.7	69.7	—
HLD AREA								
Asansol	—	—	—	—	—	—	10.5	—
Dhanbad	—	—	—	—	—	—	—	—
Rampurhat	—	—	—	—	—	—	1.9	—
Tatanagar	—	—	—	—	—	—	24.0	—
Ranohi	—	—	—	—	—	—	1.0	—
Rourkela	—	—	—	—	—	—	0.9	—

('000 tonnes)

Consumption points	Ex. New Refinery				Ex. AOC	Ex. GHT	Ex. BNI	Ex. HLD
	C.Ia	C.Ib	C.IIa	C.IIb				
Kharagpur	—	—	—	—	—	—	5.6	—
Balasore	—	—	—	—	—	—	0.2	—
Calcutta	—	—	—	—	—	37.9	11.6	—
Andaman	—	—	—	—	—	—	1.0	—
<i>Sub-Total</i>	—	—	—	—	—	37.9	56.8	—
N.W. AREA								
Aligarh	—	—	—	—	—	—	14.6	—
Barcilly	—	—	—	—	—	—	5.6	—
Moradabad	—	—	—	—	—	—	5.9	—
Meerut	—	—	—	—	—	—	9.8	—
Saharanpur	—	—	—	—	—	—	3.8	—
Ambala	—	—	—	—	—	—	12.6	—
Chandigarh	—	—	—	—	—	—	1.9	—
Simla	—	—	—	—	—	—	0.2	—
Patiala	—	1.2	—	1.2	—	—	6.8	—
Ludhiana	—	16.8	—	16.6	—	—	—	—
Jullundur	—	20.5	—	20.5	—	—	—	—
Mandi	—	1.1	—	1.1	—	—	—	—
Pathankot	—	3.7	—	3.7	—	—	—	—
J&K	—	6.1	—	6.1	—	—	—	—
Ferozepur	—	29.2	—	29.2	—	—	—	—
Delhi	—	21.9	—	54.6	—	—	—	—
<i>Sub Total</i>	—	100.3	—	133.0	—	—	61.2	—
KOYALI AREA								
Agra	—	—	—	—	—	—	6.5	—
Farukhabad	—	—	—	—	—	—	5.8	—
<i>Sub-Total</i>	—	—	—	—	—	—	12.3	—
KDL MG AREA								
Hissar	—	—	—	26.3	—	—	—	—
Jaipur	—	—	—	33.4	—	—	—	—
Jodhpur	—	—	—	8.6	—	—	—	—
<i>Sub-Total</i>	—	—	—	68.3	—	—	—	—
Grand Total Distribution	—	101.0	—	202.0	40.0	94.0	200.0	—

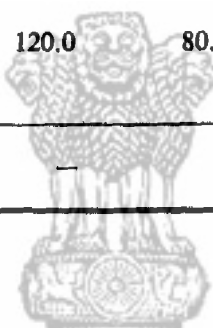
PRODUCT : FO

('000 tonnes)

Consumption Points	Ex New Refinery				Ex. AOC	Ex. GHT	Ex. BNI	Ex. HLD
	C.Ia	C.Ib	C.IIa	C.IIb				
Production	—	60.0	—	120.0	80.0	100.0	155.0	950.0
Distribution								
N. E. AREA								
Navagaon	—	—	—	—	—	3.0	—	—
Badarpur	—	—	—	—	4.0	1.6	—	—
Jorhat	—	—	—	—	26.3	—	—	—
Tinsukia	—	—	—	—	49.7	—	—	—
Manipur	—	—	—	—	—	—	—	—
Tripura	—	—	—	—	—	0.3	—	—
Gauhati	—	—	—	—	—	5.5	—	—
Tezpur	—	—	—	—	—	21.8	—	—
Alipurduar	—	—	—	—	—	23.8	—	—
Bhutan	—	—	—	—	—	—	—	—
Siliguri	—	—	—	—	—	1.3	—	—
Sikkim	—	—	—	—	—	—	—	—
Sub-Total	—	—	—	—	80.0	57.3	—	—
BNI AREA								
Katihar	—	—	—	—	—	0.5	—	—
Muzaffarpur	—	—	—	—	—	9.1	—	—
Nepal	—	—	—	—	—	1.6	—	—
Gorakhpur	—	—	—	—	—	3.8	—	—
Bhagalpur	—	—	—	—	—	—	—	15.6
Patna	—	—	—	—	—	—	2.4	—
Gaya	—	—	—	—	—	—	23.0	—
Varanasi	—	—	—	—	—	—	91.2	—
Allahabad	—	—	—	—	—	—	1.6	—
Satna	—	—	—	—	—	—	4.8	—
Kanpur	—	60.0	—	120.0	—	—	12.6	—
Lucknow	—	—	—	—	—	—	6.0	—
Sitapur	—	—	—	—	—	—	—	—
Shahajahanpur	—	—	—	—	—	—	—	—
Sub-Total	—	60.0	—	120.0	—	15.0	141.6	15.6
HLD AREA								
Asansol	—	—	—	—	—	—	—	79.3
Dhanbad	—	—	—	—	—	—	—	6.7
Rampurhat	—	—	—	—	—	—	—	—
Tatanagar	—	—	—	—	—	—	—	40.6
Ranchi	—	—	—	—	—	—	—	19.3
Rourkela	—	—	—	—	—	—	—	9.3
Kharagpur	—	—	—	—	—	—	—	4.7

('000 tonnes)

Consumption points	Ex. New Refinery				Ex. AOC	Ex. GHT	Ex. BNI	Ex. HLD
	C.Ia	C.Ib	C.IIa	C.IIb				
Balasore	—	—	—	—	—	—	—	—
Calcutta	—	—	—	—	—	—	—	347.6
Andaman	—	—	—	—	—	—	—	0.3
Sub-Total	—	—	—	—	—	—	—	506.9
N.W. AREA								
Aligarh	—	—	—	—	—	27.7	13.4	11.3
Bareilly	—	—	—	—	—	—	—	6.7
Moradabad	—	—	—	—	—	—	—	5.3
Meerut	—	—	—	—	—	—	—	28.8
Saharanpur	—	—	—	—	—	—	—	5.9
Sub-Total	—	—	—	—	—	27.7	13.4	56.0
GRAND TOTAL	—	60.0	—	120.0	80.0	100.0	155.0	578.5
DISTRIBUTION								
Surplus	—	—	—	—	—	—	—	371.5



सत्यमेव जयते

ANNEXE XI-G

PRODUCT : CALCINED COKE

('000 tonnes/Year)

<i>Plant name</i>	<i>Location</i>	<i>Aluminium Production Capacity</i>	<i>Demand for Calcined Coke</i>
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Northern & Eastern Region :**(a) Existing Plants**

(i) Indian Aluminium Co.	Hirakud	20.0	9.0
(ii) Aluminium Corporation of India	Asansol	9.0	4.1
(iii) Hindustan Aluminium	Renukoot	75.0	33.8
Sub Total		104.0	46.9

(b) Proposed new capacity/expansion of existing units

(i) Aluminium Corporation of India	Asansol	3.5	1.6
(ii) Hindustan Aluminium	Renukoot	60.0	27.0
(iii) New Smelter	Orissa	30.0	13.5
(iv) Bharat Aluminium	Korba	100.0	45.0
Sub-Total		193.5	87.1
GRAND TOTAL		297.5	134.0

Calcined Coke Production & allocation ex-existing Eastern Refineries

'000 tonnes/year

Production

Gauhati	30.0
Barauni	46.5
Digboi	14.0
	90.5

Allocation

(i) Existing Aluminium Plants as above	46.9
(ii) Other miscellaneous consumers	24.0
(iii) Proposed new capacity/expansion	
(a) Aluminium Corpn. of India, Asansol	1.6
(b) New Smelter, Orissa	13.5
(c) Bharat Aluminium, Korba	4.5—Part

Calcined Coke Production & allocation ex-New Refinery

	<i>Production Case</i>	
	Ib	IIb
Production		
Production of coke	36.0	72.0
Equivalent as calcined coke	24.0	48.0
Distribution		
Hindustan Aluminium, Renukoot	24.0	27.0
Bharat Aluminium, Korba	—	21.0

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ANNEXE XII

SUMMARY OF COMPARATIVE COSTS OF TRANSPORTATION OF CRUDE OIL & REFINED PRODUCTS INCLUDING TONNE/KILOMETERS OF RAIL MOVEMENT

	FREIGHT RS. LAKH					TON. KMS. MILLION BY RAIL				
	Location of New Refinery					Location of new refinery				
	GALEKI/Nazira	Gauhati	Dhubri	Barauni	Kanpur	GALEKI/Nazira	Gauhati	Dhubri	Barauni	Kanpur
Case-A No Product PL	Ia 1184	1209	1318	1112	984	1860	1485	1369	843	219
	Ib 1169	1219	1335	1152	1094	1848	1501	1394	904	344
	IIa 2400	2347	2385	2031	1502	3793	3081	2821	1695	478
	IIb 2336	2324	2372	2057	1667	3752	3057	2817	1766	696
Case-B White Oil Product PL from new refinery to Siliguri	Ia 1356	1259	1356	1112	984	1522	1337	1270	843	219
	Ib 1258	1233	1348	1152	1094	1371	1279	1245	904	344
	IIa 2401	2312	2365	2031	1502	3076	2738	2591	1695	478
	IIb 2180	2197	2291	2057	1667	2758	2566	2487	1766	696
Case-C White Oil Product PL from new refinery to Barauni	Ia 1390	1264	1360	1112	984	1398	1213	1146	843	219
	Ib 1248	1204	1319	1152	1094	1185	1093	1059	904	344
	IIa 2357	2249	2295	2031	1502	2806	2468	2321	1695	478
	IIb 2052	2057	2139	2057	1667	2364	2172	2093	1766	696
Case-D White Oil Product PL from new refinery to Kanpur	Ia 1517	1324	1423	1196	984	1189	1004	937	569	219
	Ib 1282	1194	1314	1148	1094	868	776	742	522	344
	IIa 2373	2213	2266	1944	1502	2379	2041	1894	1166	478
	IIb 1914	1926	2079	1810	1667	1775	1583	1504	1044	696
Case-E White Oil Product PL from new refinery to Delhi	Ia 1571	1321	1414	1241	988	1047	862	795	427	77
	Ib 1255	1134	1238	1120	1033	655	563	529	309	130
	IIa 2230	2102	2178	1892	1408	2115	1777	1630	893	210
	IIb 1719	1728	1843	1674	1475	1398	1206	1127	658	316

ANNEXE XIII-A

**BREAK-UP OF TOTAL TRANSPORTATION COSTS & TON.KMS.
BY RAIL FOR CRUDE & PRODUCTS IF THE NEW
REFINERY IS LOCATED AT GALEKI/NAZIRA**

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in million			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Crude oil—by pipeline	—	—	—	—	—	—	—	—
Black oil —RFO by rail Ex. Ref.	605	243	1209	485	976	384	1913	767
FO by rail Ex. Ref.	—	72	—	145	—	117	—	234
Pet. Coke by rail Ex. Ref.	—	16	—	33	—	41	—	88
1. Sub-Total :	605	331	1209	663	976	542	1913	1089
Case A No White Oil Product PL								
2. Direct by rail Ex. Ref.	579	838	1191	1673	884	1306	1880	2663
Case A—Total (1+2)	1184	1169	2400	2336	1860	1848	3793	3752
Case B White Oil Product PL								
Ref. to SLG								
PL transportation cost	339	310	339	304	—	—	—	—
Ex. Ref. direct by rail	—	—	—	—	—	—	—	—
Ex. Intermediate tap off points by rail	8	8	8	8	9	9	9	9
Ex. SLG terminal by rail	404	609	845	1205	537	820	1154	1660
3. Sub-Total :	751	927	1192	1517	546	829	1163	1669
Case B—Total : (1+3)	1356	1258	2401	2180	1522	1371	3076	2758
Case C White Oil Product PL								
Ref. to BNI.								
PL transportation cost	446	407	455	413	—	—	—	—
Ex. Ref. direct by rail	—	—	—	—	—	—	—	—
Ex. Intermediate tap off points by rail	8	8	8	8	9	9	9	9
Ex. BNI by rail	331	502	685	968	413	634	884	1266
4. Sub-Total :	785	917	1148	1389	422	643	893	1275
Case C—Total (1+4)	1390	1248	2357	2052	1398	1185	2806	2364
Case D White Oil Product PL								
Ref. to KNP.								
PL transportation cost	714	650	740	632	—	—	—	—
Ex. Ref. direct by rail	—	—	—	—	—	—	—	—
Ex. Intermediate tap off points by rail	8	8	37	83	9	9	29	60
Ex. Kanpur by rail	190	293	387	536	204	317	437	626
5. Sub-Total :	912	951	1164	1251	213	326	466	686
Case D—Total (1+5)	1517	1282	2373	1914	1189	868	2379	1775

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in million			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Case E White Oil Product PL								
Ref. to Delhi								
PL transportation cost	897	815	821	742	—	—	—	—
Ex. Ref. direct by rail	—	—	—	—	—	—	—	—
Ex. Intermediate tap off points by rail	8	8	45	91	9	9	38	69
Ex. Delhi, by rail	61	101	165	223	62	104	164	240
6. Sub-Total :	966	924	1021	1056	71	113	202	309
Case E—Total (1+6)	1571	1255	2230	1719	1047	655	2115	1398



ANNEXE XIII-B

BREAK-UP OF TOTAL TRANSPORTATION COSTS AND TON. KMS.
BY RAIL FOR CRUDE AND PRODUCTS IF THE NEW
REFINERY IS LOCATED AT GAUHATI

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Crude oil—by pipeline	200	200	280	280	—	—	—	—
Black oil-RFO by rail Ex. Ref.	510	205	1020	409	779	313	1558	625
FO by rail Ex. Ref.	—	61	—	122	—	93	—	186
Pet. Coke by rail Ex. Ref.	—	13	—	28	—	32	—	69
1. Sub Total :	710	479	1300	839	779	438	1558	880
Case A No White Oil Product PL								
2. Direct by rail Ex. Ref.	499	740	1047	1485	706	1063	1523	2177
Case A—Total (1+2)	1209	1219	2347	2324	1485	1501	3081	3057
Case B White Oil Product PL								
Ref. to SLG.								
PL transportation cost	126	126	143	129	—	—	—	—
Ex. Ref. direct by rail	19	19	24	24	21	21	26	26
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. SLG terminal by rail	404	609	845	1205	537	820	1154	1660
3. Sub-Total :	549	754	1012	1358	558	841	1180	1686
Case B—Total (1+3)	1259	1233	2312	2197	1337	1279	2738	2566
Case C White Oil Product PL								
Ref. to BNI.								
PL transportation cost	204	204	240	226	—	—	—	—
Ex. Ref. direct by rail	19	19	24	24	21	21	26	26
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. BNI by rail	331	502	685	968	413	634	884	1266
4. Sub-Total :	554	725	949	1218	434	655	910	1292
Case C—Total (1+4)	1264	1204	2249	2057	1213	1093	2468	2172
Case D White Oil Product PL								
Ref. to KNP								
PL transportation cost	405	403	473	452	—	—	—	—
Ex. Ref. direct by rail	19	19	24	24	21	21	26	62
Ex. Intermediate tap off points by rail	—	—	29	75	—	—	20	51
Ex. Kanpur by rail	190	293	387	536	204	317	437	626
5. Sub-Total :	614	715	913	1087	225	338	483	703
Case D—Total (1+5)	1324	1194	2213	1926	1004	776	2041	1583

Production Schemes	Freight Cost. Rs. Lakhs.				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Case E White Oil Product PL								
Ref. to Delhi								
PL transportation cost	531	535	586	559	—	—	—	—
Ex. Ref. direct by rail	19	19	24	24	21	21	26	26
Ex. Intermediate tap off points by rail	—	—	36	83	—	—	29	60
Ex. Delhi by rail	61	101	155	223	62	104	164	240
6. Sub-Total :	611	655	802	889	83	125	219	326
Case E-Total (1+6)	1321	1134	2102	1728	862	563	1777	1206



ANNEXE XIII-C

**BREAK-UP OF TOTAL TRANSPORTATION COSTS AND TON. KMS.
BY RAIL FOR CRUDE AND PRODUCTS IF THE NEW
REFINERY IS LOCATED AT DHUBRI**

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Crude oil-by pipeline	360	360	440	440	—	—	—	—
Black oil-RFO by rail Ex. Ref.	472	189	944	379	701	281	1403	563
FO by rail Ex. Ref.	—	57	—	113	—	84	—	168
Pet. Coke by rail Ex. Ref.	—	12	—	26	—	28	—	62
1. Sub-Total :	832	618	1384	958	701	393	1403	793
Case A No White Oil Product PL								
2. Direct by rail Ex. Ref.	486	717	1001	1414	668	1001	1418	2024
Case A-Total (1+2)	1318	1335	2385	2372	1369	1394	2821	2817
Case B White Oil Product PL Ref. to SLG								
PL transportation cost	91	92	105	97	—	—	—	—
Ex. Ref. direct by rail	29	29	31	31	32	32	34	34
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. SLG terminal by rail	404	609	845	1205	537	820	1154	1660
3. Sub-Total :	524	730	981	1333	569	852	1188	1694
Case B-Total (1+3)	1356	1348	2365	2291	1270	1245	2591	2487
Case C White Oil Product PL Ref. to BNI								
PL transportation cost	168	170	195	182	—	—	—	—
Ex. Ref. direct by rail	29	29	31	31	32	32	34	34
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. BNI by rail	331	502	685	968	413	634	884	1266
4. Sub-Total :	528	701	911	1181	445	666	918	1300
Case C - Total (1+4)	1360	1319	2295	2139	1146	1059	2321	2093
Case D White Oil Product PL Ref. to KNP								
PL transportation cost	372	374	435	419	—	—	—	—
Ex. Ref. direct by rail	29	29	31	31	32	32	34	34
Ex. Intermediate tap off points by rail	—	—	29	75	—	—	20	51
Ex. Kanpur by rail	190	293	387	536	204	317	437	626
5. Sub-Total :	591	696	882	1061	236	349	491	711
Case D-Total (1+5)	1423	131n	2266	2019	937	742	1894	1504

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Case E White Oil Product PL								
Ref. to Delhi								
PL transportation cost	492	490	571	548	—	—	—	—
Ex. Ref direct by rail	29	29	31	31	32	32	34	34
Ex. Intermediate tap off points by rail	—	—	37	83	—	—	29	60
Ex. Delhi by rail	61	101	155	223	62	104	164	240
6. Sub-Total :	582	620	794	885	94	136	227	334
Case E-Total (1+6)	1414	1238	2178	1843	795	529	1630	1127



ANNEXE XIII-D

**BREAK UP OF TOTAL TRANSPORTATION COSTS AND TON. KMS.
BY RAIL FOR CRUDE AND PRODUCTS IF THE NEW
REFINERY IS LOCATED AT BARAUNI**

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Crude oil—by pipeline	440	440	700	700	—	—	—	—
Black Oil—RFO by rail Ex. Ref.	287	115	573	230	359	144	717	288
FO by rail Ex. Ref.	—	34	—	69	—	43	—	86
Pet. Coke Ex. Ref.	—	7	—	17	—	12	—	32
1. Sub-Total :	727	596	1273	1016	359	199	717	406
Case A White Oil Product PL								
2. Direct by rail Ex. Ref.	385	556	758	1041	484	705	978	1360
Case A—Total (1+2)	1112	1152	2031	2057	843	904	1695	1766
Case B White Oil Product PL								
Ref. to SLG.								
PL transportation cost	NOT APPLICABLE							
Ex. Ref. direct by rail	385	556	758	1041	484	705	978	1360
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. SLG terminal by rail	—	—	—	—	—	—	—	—
3. Sub-Total :	385	556	758	1041	484	705	978	1360
Case B—Total (1+3)	1112	1152	2031	2057	843	904	1695	1766
Case C White Oil Product PL								
Ref. to BNI.								
PL transportation cost	NOT APPLICABLE							
Ex. Ref. Direct by rail,	385	556	758	1041	484	705	978	1360
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. BNI by rail	—	—	—	—	—	—	—	—
4. Sub-Total :	385	556	758	1041	484	705	978	1360
Case C—Total (1+4)	1112	1152	2031	2057	843	904	1695	1766
Case D White Oil Product PL								
Ref. to KNP.								
PL transportation cost	273	253	274	248	—	—	—	—
Ex. Ref. direct by rail	6	6	10	10	6	6	12	12
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. Kanpur by rail	190	293	387	536	204	317	437	626
5. Sub-Total :	469	552	671	794	210	323	449	638
Case D—Total (1+5)	1196	1148	1944	1810	569	522	1166	1044

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Case E White Oil Product PL								
Ref. to Delhi								
PL transportation cost	47	417	424	425	—	—	—	—
Ex. Ref. direct by rail	6	6	10	10	6	6	12	12
Ex. Intermediate tap off points by rail								
Ex. Delhi by rail	61	101	155	223	62	104	164	240
6. Sub-Total :	514	524	619	658	68	110	176	252
Case E—Total (1+6)	1241	1120	1892	1674	427	309	893	658



**BREAK-UP OF TOTAL TRANSPORTATION COSTS AND TON. KMS.
BY RAIL FOR CRUDE AND PRODUCTS IF THE NEW
REFINERY IS LOCATED AT KANPUR**

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Crude Oil-by pipeline	780	780	1080	1080	—	—	—	—
Black Oil-RFO by rail Ex. Ref.	—	—	—	—	—	—	—	—
FO by rail Ex. Ref.	—	—	—	—	—	—	—	—
Pet. Coke by rail Ex. Ref.	—	7	—	16	—	11	—	30
1. Sub-Total :	780	787	1080	1096	—	11	—	30
Case A White Oil Product PL								
2. Direct by rail Ex. Ref.	204	307	422	571	219	333	478	666
Case A-Total (1+2)	984	1094	1502	1667	219	344	478	696
Case B White Oil Product PL								
Ref. to SLG.								
PL transportation cost			NOT APPLICABLE					
Ex. Ref. direct rail	204	307	422	571	219	333	478	666
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. SLG terminal by rail	—	—	—	—	—	—	—	—
3. Sub-Total :	204	307	422	571	219	333	478	666
Case B-Total (1+3)	984	1094	1502	1667	219	344	478	696
Case C White Oil Product PL								
Ref. to BNI								
PL transportation cost			NOT APPLICABLE					
Ex. Ref. direct by rail	204	307	422	571	219	333	478	666
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. BNI by rail	—	—	—	—	—	—	—	—
4. Sub-Total :	204	307	422	571	219	333	478	666
Case C - Total (1+4)	984	1094	1502	1667	219	344	478	696
Case D White Oil Product PL								
Ref. to KNP								
PL transportation cost			NOT APPLICABLE					
Ex. Ref. direct by rail	204	307	422	571	219	333	478	666
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. Kanpur by rail	—	—	—	—	—	—	—	—
5. Sub-Total :	204	307	422	571	219	333	478	666
Case D - Total (1+5)	984	1094	1502	1667	219	344	478	696

Production Schemes	Freight Cost Rs. Lakhs				Ton. Km. by rail in millions			
	Ia	Ib	IIa	IIb	Ia	Ib	IIa	IIb
Case E White Oil Product PL								
Ref. to Delhi.								
PL transportation cost	133	131	130	113	—	—	—	—
Ex. Ref. direct by rail	14	14	43	43	15	15	46	46
Ex. Intermediate tap off points by rail	—	—	—	—	—	—	—	—
Ex. Delhi by rail	61	101	155	223	62	104	164	240
6. Sub-Total :	208	246	328	379	77	119	210	286
Case E - Total (1+6)	988	1033	1408	1475	77	130	210	316

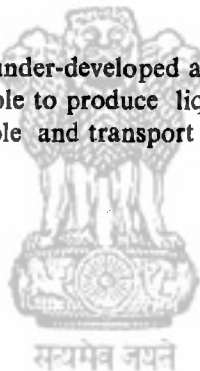


COPY OF THE MINUTE RECORDED BY DR. TRIGUNA SEN, MINISTER P & C
AND M&M DATED 2ND JULY 1969.

As Secretary is aware we had issued Resolution No. 25(1)/68-OR setting up an Experts' Committee to go into the question of the crude oil resources of Assam and work out the techno-economic feasibility and comparative economics of establishing a new Refinery in Assam.

Since the Experts' Committee is seeking an extension of time to complete its work, I suggest that you may also ask this Committee to examine how best the additional crude that is likely to be produced in Assam can be utilised within Assam itself apart from refining it to produce conventional products or transporting it outside the State for refining elsewhere.

With a view to develop this under-developed and strategic part of the country I think it is necessary to see if it is feasible to produce liquid ammonia, aromatics and the like as near the production site as possible and transport them to other parts of the country for production of fertilisers etc.



FIRST AMMONIA LINE STARTS UP

(G. V. ROHLER, Vice-President Mid-America Pipeline Co., The Oil and Gas Journal

Oct. 28, 1968) 113-117

(Notes and Extracts from the article).

MID-AMERICA pipeline System, a division of MAPCO, Inc., Tulsa, Okla., has completed a major common carrier pipeline system devoted exclusively to the transportation of anhydrous ammonia.

The system extends from Borger, Tex. to Garner, Ogden and Sanborn, Iowa.

The pipeline parallels Mid-America's existing LP-gas system to Whiting, Iowa.

Total length of the system is approximately 850 miles.

Design, construction: The pipeline was divided into five sections to facilitate control and material delivery.

The pipeline was designed in accordance with USAS B 31.4 Standard for Pressure Piping, and the requirements of the Department of Transportation.

It consists of 6 and 8-in pipe, used interchangeably to provide the optimum cost of construction and operation for the ultimate capacity. Initial capacity will be 1,300 tons/day

This will be expanded to 3,000 to 5,000 tons/day with the installation of booster stations which are being provided for at this time. Additional stations will provide the ultimate capacity of 5,000 tons/day

Operating pressures will be a maximum of 1,560 psig on the 6-in. portions of the line, and 1,200 psig on the 8-in. Under these conditions the pipe will be operating at a maximum of 72% of the minimum yield strength of the pipe.

All cross-country pipe is API 5LX46, electric resistance weld with a wall thickness of 0.156 in., and an average joint length of 60 ft. The chemistry limitations are: carbon 0.25% maximum; manganese 0.7 to 1.0%; and residual copper 0.15% maximum.

To hold the copper within the limits, all scrap used in the steel-making process was graded. The complete tube was normalized at a temperature from 1,600°F. to 1,700°F.

Pipe for major stream crossing is 0.250 in. wall thickness instead of 0.156. Steel for main-line valves and fittings was specially ordered to comply with the pipe-chemistry limitations.

All valves are cast steel, weld end. Piping fabrications requiring branch connections and other openings were stress relieved after the welding process was completed.

Block valves are set above ground with an average spacing of 10 miles, and a maximum spacing of 12 miles.

Note: Due to shortage of time, it was not possible to obtain the permission of the journals for reprinting the articles. In the report submitted by the committee, photostat copies of the articles are attached. In this printed report summaries of the articles have been included.

The pipe has a normal cover of 36 in. except at stream, highway, and railroad crossings where the minimum is 48 in. Highway and railroad crossings are cased, in the case of some country roads depending on the local requirements.

All girth welds were made with stick electrodes. Three beads were run, the stringer with E6010 rods and the hot pass and cap with E7010 rods. Welds were radiographed 100% at stream, highway, and railroad crossings. Fifteen percent of all other welds were radiographed on the cross-country pipe.

Coating consists of a 12 to 13-mil tape with primer plus an outer wrap of 80-lb kraft paper. Application was over-the-ditch with a hydraulically loaded machine that cleans, primes, tapes, and wraps in a single operation.

A 40-mil tape was used as rock shield where needed, and was applied over the tape system without the kraft paper. The 40-mil tape was applied with the same tape machine. All cased crossings were double-taped.

At major stream crossings, the coating system is 3/32-in. coal tar enamel with 15-lb glass-reinforced outerwrap. Where rock shield was required, the 40-mil tape was used. This coating system was yard applied.

The line was hydrostatically tested for 24 hr. by the prime contractor to a minimum of 90% and a maximum of 95% of minimum yield.

For the 6-in. pipe this is equivalent to 1,950 psig minimum and 2,060 psig maximum; for the 8-in. 1,490 psig minimum and 1,570 maximum.

Testing was done in approximately 20-mile sections with a recording dead-weight gauge on both ends of the section. Following a successful test the water was displaced with air scrapers.

Pump stations : Pump stations are located at Borger, Tex., Conway, Kan., and Early, Iowa. Electric motors drive centrifugal pumps at all stations except at Borger where there are two.

The unit is equipped for suction, case and discharge pressure telemetering and has normal suction, case, and discharge-pressure safety switches.

The motor has bearing and winding temperature protective devices, and the pump has bearing and hot-case temperatures, vibration, and seal-failure shut-down switches. The hot-case temperature switch has a low-flow switch for backup protection.

Economics : Development of anhydrous ammonia pipeline transportation system is tied to agricultural economics.

Long distance ammonia pipeline transportation costs have a competitive advantage over costs of transporting ammonia by rail, truck and barge when large amounts are involved.

Storage, handling : Dual use of pumping equipment to pump LP-gas as ammonia is possible.

Mid-America is also studying batching techniques. If feasible, anhydrous ammonia may be batched in the LP-gas system if needed.

SPREADS DIG IN ON BIG AMMONIA LINE

(Summary of an article by *John P. O'Donnell*, Pipeline Editor, *Oil & Gas Journal*, Oct, 21, 1968, p. 56-57)

The longest pipeline project undertaken in the U. S. in 5 years will stretch 2,000 miles from Gulf Coast plants to consuming areas in Nebraska and N. E. Indiana and will supply that area with 3 million tons/year of anhydrous ammonia fertilizer. There will be 14 river crossings two of which will be across the Mississippi and the Missouri. Pipe diameters will vary from 3" to 10". The 10" main line will be 548 miles long. A remote control centre at Hermann, Mo. will initially handle 3 main line stations. Ultimately there will be 13 stations on the 10" line plus nine on the west and five on the east lateral.

All stations will have two pumps operating in series and a third as spare in each main line station. Initial horse-power will be 8,800 and ultimate 55,000.

Main line shut off valves will be located at 10-mile intervals. Those at stations and major river crossings will have sensing units which will automatically shut off sections in the event of a leak. Minimum cover is 36" and 48" in certain areas. Terminals will be spaced at not greater than 75-mile intervals.



AMMONIA LINE HAS UNUSUAL FEATURES

(John J. Lee, Vice-President, Sales, Gulf Central Pipeline Co. The Oil and Gas Journal, Nov. 4, 1968, 103-108)

(From a paper delivered at the American Chemical Society annual meeting, Atlantic City, N. J., Sept. 10, 1968)

(Notes and Extracts from the article)

GULF CENTRAL Pipeline is an independently owned and operated common carrier pipeline system dedicated to the service of producers and marketers of anhydrous ammonia.

It was organized to build and operate a pipeline to transport ammonia from the major producing regions along the Texas and Louisiana Gulf Coast to the Corn Belt and to distribute it in the major consuming areas in Iowa, Illinois, Nebraska, Indiana, and Missouri.

Product characteristics : Anhydrous ammonia (NH_3) is three parts hydrogen and one part nitrogen by volume or about 82% nitrogen and 18% hydrogen by weight. At -28°F . and atmospheric pressure, it is a liquid at its normal boiling point.

At higher temperatures and atmospheric pressure, ammonia is a colorless gas with a pungent odor and a density lighter than air.

It has a flammability limit of 16 to 27% by volume in air at atmospheric pressure and an ignition temperature of $1,204^\circ \text{F}$. in an iron bomb having catalytic effects. Anhydrous ammonia is completely miscible in water, Table 2,

Table I

Anhydrous ammonia specifications

Ammonia	99.5% minimum by weight
Water	0.2% minimum by weight
Oil	4 ppm maximum
Inerts	0.5 cc per g. maximum
Temperature	35°F . minimum— 85°F . maximum
Pressure	300 psig minimum— 1,450 psig maximum

Table 2

Anhydrous ammonia

Chemical formula NH_3 Weight per gallon of liquid at	60° F 5.15 lbs.
Sp. gr of gas (air = 1) at	60° F. 0.588
Sp. gr of liquid (water = 1) at	60° F 0.617
Boiling point at 1 atm	-28° F.
Vapor pressure at 0° F.	16 psig
at 70° F.	114 psig
at 100° F.	198 psig
One cu ft of liquid at 60° F. expands to	850 scf of vapor
Flammability limit in air at atmospheric pressure	16%—27%
Solubility in water 0° C.	89.9 parts per 100 parts
at 96° C.	7.4 parts per 100 parts
Odor detectable level	50 ppm

Anhydrous ammonia is a liquid at pressure at or above its vapor pressure in a closed system. As an example, the vapor pressure of liquid ammonia at 70° F. is 114 psig. It will be shipped as a liquid by Gulf Central.

Normal flowing temperature will range between 35° F. and 75° F. and will be a function of ground-temperature conditions.

Ammonia will vigorously attack copper, silver, zinc, and many alloys, especially those containing copper, such as brass and bronze. This fact is very important in system metallurgy. Iron and steel are generally suitable for anhydrous ammonia service.

The effect of anhydrous ammonia on personnel varies depending upon its physical state and concentration. The effects of ammonia in the gaseous state will vary from mild irritation to severe corrosion of the sensitive membranes of the eyes, nose, throat, and lungs.

Ammonia acts as its own detector at very low concentrations due to its sharp pungent odor. At concentrations of 50 ppm in air, it has a slight detectable odor. At 100 ppm in air, no adverse effects occur for the average unprotected worker for an 8 hr daily exposure. Concentrations of ammonia ranging from 400 to 700 ppm will cause irritation to the throat and eyes.

Ordinarily no serious results will follow in frequent short exposures of less than an hour. Convulsive coughing and severe eye irritation occur when a person is exposed to vapor concentrations running from 2,000-3,000 ppm ammonia in air.

No permissible exposure is allowed and these concentrations could be fatal after short exposure. Any exposure in concentrations of 5,000 to 10,000 ppm is rapidly fatal.

Pipe specification: While anhydrous ammonia does not attack steel, contaminants in ammonia, such as carbon dioxide and air, can cause stress-corrosion cracking. Normal pipeline operating conditions will exclude carbon dioxide and air. In addition all ammonia transported will contain at least 0.2% water (2,000 ppm).

Although 0.2% water in anhydrous ammonia effectively inhibits stress corrosion in steel, the pipe specifications for the Gulf Central pipeline specify a steel that would further avoid the possibility of stress corrosion and prevent pipeline ruptures.

Metallurgical aspects of transporting anhydrous ammonia by pipeline in 6, 8, and 10-in. sizes at a maximum pressure of 1,440 psia and a temperature range of +35° F. to +75° F. were studied. Based on this study, X-42 pipe having a minimum yield strength of 42,000 psi was chosen instead of a higher strength grade such as X-46 or X-52 normally used on LP-gas pipelines.

Prevention of residual stresses in the pipe can be accomplished in part by the grade selection. The grade with the lowest strength probably would have the lowest internal residual stress and should be the best choice.

Grade B pipe, having a lower strength than X-42, was considered in practice, however, most steel companies furnish X-42 for Grade B as an economy in pipe manufacture.

According to code stipulations, the pipe wall thickness required for a given operating pressure varies inversely as the pipe grade specified.

For example, at the same design operating pressure, a pipeline constructed with X-42 pipe would require a wall thickness 23.8% greater than X-52 and 9.5% greater than X-46.

While anhydrous ammonia does not attack steel, it rapidly corrodes zinc, tin, copper, and copper-base alloys. The copper content in the pipe has been limited to a maximum of 0.15%.

Maximum transition temperature of the pipe has been set as 0°F. This is substantially below the 35°F. to 75°F. normal operating temperature range of the system. At operating temperatures above the transition temperature, pipe failures are largely shear ductile failures. At temperatures below the transition temperature, failures are predominantly brittle fractures.

Shear failures are localized whereas brittle fractures have been known to propagate along the pipeline at a velocity approaching the speed of sound. The length of a pipeline affected by a possible rupture could be quite large if a brittle fracture occurred whereas a shear fracture would be completely localized.

ERW pipe is specified and it is furnished in the nonexpanded condition with no cold expanding after forming and welding. Testing of the steel for the pipe includes ladle analysis, transverse tensile properties, weld tensile, and flattening tests.

In performing the weld-tensile test, Charpy V-notch impact tests are performed on the plate center of the weld and heat affected zones.

Each section of pipe is heat treated and hydrostatically tested at 1,760 psig. The non-destructive testing includes testing of all welded seams by radiological, ultrasonic or electromagnetic methods after heat treating and hydrostatic testing are performed. All pipe will be inspected by a representative of Gulf Central.

Safety considerations: The pipeline system will conform to the Department of Transportation (DOT) regulations covering the transportation of hazardous materials by pipeline. It will also conform

to the ASA B 31.4-Liquid Petroleum Transportation Code and to the ASA B31.8 Gas Transmission Code, where the latter is more stringent.

This resulted in heavier wall pipe where the population density index dictates. The population index criteria are not generally used in the design of comparable LP-gas pipeline systems.

The pipeline route crosses open agricultural and barren lands wherever practical to avoid densely populated areas. Pump station and terminal sites are located in areas of low habitation.

At major river and water crossings, Grade B seamless pipe of 1/2-in. wall thickness will be used. This is considerably heavier than normally required.

Main-line shutoff valves are normally installed in open areas at intervals not to exceed 20 miles. As an added precaution, Gulf Central Pipeline, will install these valves at approximately 10-mile intervals.

On the 8-in. and 10 in. trunk lines, check valves will be installed at each main-line valve. These valves will be an additional safeguard in event of a line break, since all contents of the line ahead of the rupture would be prevented from flowing backwards to the rupture point.

Pump-station locations and major river crossings will have sensing equipment which can detect line breaks or ruptures by the resultant sudden changes of flow. It will activate automatic shutoff valves and isolate the rupture in a section.

Construction specifications call for a minimum of 36 in. cover. In areas where deep plowing methods are used, 48 in. cover will be provided.

Warning signs and markers will be installed in conspicuous locations along the pipeline route in greater number than normal.

After the pipeline is laid and tested, it will be purged and filled and remain filled with ammonia so that no air or oxygen can be admitted.

Pipeline Hydraulics : Maximum working pressures are dictated by the size and schedule of pipe. These are 1,407 psig for the 10 in., 1,424 psig for the 8 in. and 1,426 psig for the 6 in. Minimum operating pressure of 300 psig insures that the ammonia remains in a liquid state. These pressures will be reviewed for conformity with the DOT regulation when they are finalized.

Ultimate projected flow for the 10 in. main line and 8 in. laterals determined the number and location of present and future pump stations. The ultimate flow rate of 3 million tons/year for the main line and 1.7 million tons/year for each 8 in. lateral are referred to as Phase III...

Basic pressure drop calculations determined that 16 pump stations would be required on the 10 in. main line including one at the start of the 8 in. laterals...

The initial, or Phase I, flow rates were based on 1.1 million tons/year for the main line and 1 million tons/year for each lateral. The minimum number of stations was selected from the Phase III design criteria which would fulfill the pumping requirements for Phase I.

Station design : Once the number and location of the pump stations were specified, horsepower calculations for all pump stations were made for the three phases. A field survey concluded that electrical power was available for all requirements, permitting all pumps to have electric-motor drives.

Since efficiency is a prime factor in the operating cost of a pipeline, high efficiency over the design range of flow rates was a major objective in the final choice of main and lateral-line pumps. Multi-stage pumps having the flexibility of reducing differential head and installed horsepower without sacrificing flow rates were selected. These are horizontally split-case pumps which allow for easy maintenance.

Installed horsepower for initial and ultimate designs are 8,800 and 55,000 respectively.

Safety Is Prime Concern In Ammonia Pipeline design

(Summary of an article by *W. A. Inkofer*, Process Engineer, Gulf Central Pipeline Co.,
The Oil & Gas Journal, Nov. 11, 1968 pp. 74-78)

All-welded pipelines have achieved an outstanding record for safe and dependable operation. Better streets, better welding and inspection techniques and advanced design and safety features ensure that pipeline transportation of anhydrous ammonia is a distinct improvement over present transportation methods both from the standpoint of economics and public safety. The occurrence of a pipeline break or leak in a well constructed and operated pipeline is relatively rare. However, if one does occur, an understanding of the behaviour of ammonia under such circumstances and the action to be taken to minimize the dangers, is necessary.

Large rupture : When this happens, downstream check valves would close and upstream line break detector would close main-line shut down valve at upstream station, where pumps would automatically shut down. Low-pump-suction shut down controls at all downstream stations would shut as also upstream stations due to rapid decline in pressure. High pressure spurt of ammonia would quickly subside as pipeline pressure is vented.

Liquid ammonia is relatively incompressible. The driving force for ammonia escaping from the rupture would be the vapor pressure of ammonia i.e. 107 psia at 60°F. Vaporized liquid forms a series of vapor locks in humps in the line, which greatly reduce the flow out of the rupture. It is thought that the discharge of ammonia at rupture will quickly become a lengthy, spasmodic erection of liquid and vapor combination. Flashing of liquid in the pipeline will cool the remaining liquid thus lowering the vapor pressure and, therefore, the driving force.

External conditions : Immediately after a rupture, a moment any discharge of high pressure ammonia liquid occurs which will flash to gas. This is followed by liquid ammonia which collects in pools in low spots. As the liquid evaporates it will cool and reach -28° F. The evaporation rate is fairly slow (1 to 7 lb/hr/sq. ft of surface area). A relatively small area will, therefore, contain a large volume of liquid ammonia.

A 10-mile section of a 10" line contains 591 tons (24,990 c. ft), of ammonia at 60° F. Assuming that 90% by weight will remain as liquid at -28° F during a line break, this quantity of ammonia could be entrapped as follows :

Depth (in.)	Sq. ft.	Side of Square in ft.	Acres
24	12,495	112	0.29
12	24,990	158	0.57
6	49,980	224	1.15
4	74,970	274	1.72
2	149,940	387	3.44

In the worst case, the spill is confined to a relatively small area.

Repair procedures : Main-line pipeline valves between the two pumping stations between which the rupture is located will be closed. Concerned blow down valves will be opened and ammonia vented. This will accelerate the formation of vapor locks and reduce the ammonia spill volume. Attempts will be made to contain the ammonia spill in a compact area by diking and evacuating people and animals directly adjacent and down wind of the rupture. After the liquid pool subsides, ruptured section can be cut out and new piece inserted.

If working conditions at rupture prevent this action, stopple plugs can be inserted on each side of the rupture, the flow stopped and repairs made. Stopple plugs are expansible devices which can be inserted into operating pipelines under pressure to shut off the flow, and can be removed without affecting pipeline service.

Small leaks will generally freeze the ground around the pipe and tend to contain itself. Leaking ammonia would mainly be gas and liquid spills are not anticipated. Repairs can be made by uncovering the pipeline and installing a permanent or temporary patch.



Ammonia, Buffered By Isopropanol, Can Be Batched In Hydrocarbon Pipeline

(Summary of an article by *Richard L. Every*, Continental Oil Co. in *Oil & Gas Journal*, July 29, 1968 p. 80-81).

The increasing domestic demand for ammonia (in the USA) will put additional burden on present methods of transportation—barges, tank-trucks and rail tank cars.

Separate ammonia pipelines are likely to be relatively idle at certain times of the year due to seasonal nature of demand. A better solution is to ship ammonia intermittently in existing hydrocarbon pipelines. The associated technical problems are formidable but have been overcome to make the simultaneous transport of liquid ammonia and hydrocarbon technically feasible (U. S. Patent 3198201).]

Attempts to inject a batch of liquid ammonia between No. 2 fuel oil and regular gasoline were unsuccessful in a 2 mile test loop constructed with 2" carbon steel due to differences in density and relative immiscibility of ammonia and hydrocarbon. The less dense ammonia tended to ride over the petroleum products and to collect in the high spots in the line and to contaminate the passing hydrocarbon to about 5%—the limit of its solubility. The use of neoprene spheres and batching pigs to physically separate ammonia and hydrocarbon was not successful. An alternative method would be to inject a buffer which is compatible and miscible in both ammonia and hydrocarbon. With both isopropanol and isopropylamine buffer there was no problem either of over-riding or contamination of either product by the other.

Isopropanol was an acceptable buffer because it was non-toxic and its disposal at the pipeline terminal would present no problem. Addition of 5% isopropanol to regular gasoline does not only harmfully alter the physical properties of the gasolines but increases the octane rating. Safety considerations and high cost are distinct disadvantages in commercial application of isopropylamine.

The results from the 2-mile test loop have been verified over 40 miles of an operating 6" pipeline. About 150 bbl of anhydrous liquid ammonia were buffered between iso-propanol in a normal shipment of regular gasoline. Injection and recovery were accomplished without incident and the inter-face growth of alcohol-gasoline and alcohol-ammonia were less than that had been predicted.

Ammonia did not accumulate in high spots nor was there a tendency to over ride. Isopropanol and ammonia acted as scrubber for pipeline impurities which were contained in the leading portion of the alcohol-ammonia and ammonia-alcohol interfaces. There was no difficulty in distilling and separating the two components.

Acetone or alcohol buffer between a regular hydrocarbon shipment and an aqueous solution (of fertilizer) could have great commercial significance in seasonal shipments.

Conclusion : Non-hydrocarbon systems can be successfully moved in a pipeline provided the non-hydrocarbon is physically separated from the hydrocarbon either by a batching pig or by the injection of a third component which is miscible in both the hydrocarbon and non-hydrocarbon between the two.